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THE CONSTITUTION OF MATTER AND THE EVOLUTION OF THE ELEMENTS[1]

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SPECULATIONS as to the constitution of matter have occupied an important place in the development of scientific knowledge. The idea that all matter was composed of minute particles called atoms was put forward long ago by the Greek philosophers, and was advanced again with varying degrees of confidence by philosophic men at the dawn of the scientific age. For example, Newton suggested that matter was composed of atoms which were likened to "hard massy balls," while Robert Boyle regarded a gas to consist of atoms which were in brisk motion. The first definite formulation of the atomic theory as a scientific hypothesis was given by Dalton of Manchester in 1803 in order to explain the combination of atoms in multiple proportion. The necessity of distinguishing between the chemical atom and the chemical molecule was soon recognized, while the famous hypothesis of Avogadro that equal volumes of all gases at the same temperature and pressure contain equal numbers of molecules still further extended the usefulness of the theory. The whole superstructure of modern chemistry has been largely reared on the foundations of the atomic theory. The labors of the chemist have revealed to us the presence of more than eighty distinct types of elements, each of which has a characteristic atomic weight, and in most cases sufficiently distinct physical and chemical properties to allow of its separation from any other element by the application of suitable methods.

It has been generally assumed that all the atoms of one element are identical in shape and weight, and until a few years ago were supposed to be permanent and indestructible. The close study of the variation of chemical properties of the elements with atomic weight led Frankland and Mendelief to put forward the famous "periodic law," in which it was shown that there was a periodic variation in the chemical proper-

[1] First course of lectures on the William Ellery Hale Foundation, National Academy of Sciences, delivered at the Washington Meeting, April, 1914.

ties of elements when arranged in order of increasing atomic weight. This empirical generalization has exercised a wide influence on the development of chemistry, and the periodic law has been considered by many to indicate that all the atoms are composed of some elementary substance or protyle. It is only within the last few years that our knowledge of atoms has reached a stage to offer a reasonable explanation of this remarkable periodicity.

Time does not allow me to more than refer in passing to the important contributions of Le Bel and van' t Hoff to the structure of complex molecules, and the arrangements of the atoms in space, which has exercised such a wide and important influence on the development of organic chemistry.

While the chemist was busy disentangling the elements, determining their relative atomic weights and studying their possible combinations, the physicist had not been idle. The idea that a gas consisted of a large number of molecules in swift but irregular movement had been tentatively advanced at various times to explain some of the properties of gases. These conceptions were independently revived and developed in great detail by the genius of Clausius and Clerk Maxwell about the middle of the last century. On their theory, now known as the kinetic or dynamical theory of gases, the molecules of a gas are supposed to be in continuous agitation, colliding with each other and with the walls of the containing vessel. Their velocity of agitation is supposed to increase with temperature, and the pressure is due to the impact of the molecules of the gas on the walls of the enclosure. This theory was found to explain in a simple and obvious way the fundamental properties of gases, and has proved of great importance in molecular theory. The idea that atoms must be in brisk and turbulent motion is strongly supported by the well-known property of the interdiffusion of gases and also of liquids, and in recent years has received practically a direct and concrete proof from the study of a very interesting phenomenon included under the name "Brownian Motion." The English botanist, Brown, in 1827 discovered that small vegetable spores immersed in a liquid appeared to be in continuous motion when viewed with a high power microscope. This motion of small particles in liquids was at first supposed to be a result of temperature disturbances, but at the close of the last century the Brownian movement was shown to be a fundamental property of small particles in liquids. The whole question has been investigated in recent years with great ability and skill by Perrin. He examined in detail the state of equilibrium and of motion of minute particles in suspension in liquids. The excursions due to the Brownian movements depend mainly on the size of the particles, although influenced to some extent by the nature of the liquid. Small spheres of the size required can be produced by a variety of methods. One of the simplest used by Perrin is to allow a solution

of pure water to pour slowly out of a funnel under an alcoholic solution of gamboge or mastic. An emulsion is formed where the layers meet which consists of a great number of minute spheres. When these particles are viewed in a strong light with a high power microscope, they all exhibit the characteristic Brownian movement, *i. e.*, the particles dart to and fro in irregular and tumultuous fashion, and never appear to be at rest for more than a moment. The motions of these small particles under a microscope irresistibly convey the impression that they are hurled to and fro by the action of mysterious forces resident in the solution. Such a result is to be anticipated if the molecules of the liquid are themselves in rapid though invisible tumultuous motion of the kind outlined on the kinetic theory. The particle is very large compared with the molecule, and it is bombarded on all sides by great numbers of molecules. Occasionally the pressure due to the bombardment is for a moment greater on one side of the particle than on the other, and the particle is urged forward, until a new distribution of impacts hurls it in another direction. In fact, the movement of these particles has been found to conform exactly with that predicted by the molecular theory.

It would take too long to discuss the remarkable conclusions that Perrin has reached from a study of the distribution and motion of small particles. The particle which may be an agglomeration of many millions of molecules, behaves in many respects like the much smaller molecule. A great number of particles in a liquid do not distribute themselves uniformly under gravity, but the numbers decrease with height according to the same law as the gases in our atmosphere.

On the kinetic theory, we thus have strong evidence for believing that the atoms of matter, whether in the solid, liquid or gaseous form, are in continuous agitation and irregular motion. The velocity of agitation decreases with lowering of temperature, and at the lowest attainable temperature the motion has either ceased or become very small.

It is well known that under suitable conditions, the same type of matter can exist in three distinct forms, solid, liquid and gas. If we take the ordinary air of the room, it can be turned into a clear liquid under certain conditions of temperature and pressure, and this liquid can be frozen solid by still further lowering of the temperature. The most refractory gas of all, helium, has only recently been shown to conform with the behavior of all other gases, and to pass into a liquid at a temperature only a few degrees removed from absolute zero. The remarkable changes in appearance and physical qualities of an element in passing from one state to another is a matter of common knowledge—but it is not for that reason very easy of explanation. These changes are believed to be connected with the average distance which separates one atom or molecule from the other and their rapidity of motion. In the gas or vapor form, the molecules are, on an average, so far apart

that their mutual attractions are relatively unimportant. With lowering of temperature, the distance and rapidity of motion of the molecules diminish until under certain conditions, the attraction of the molecules for one another predominates, resulting in a much closer packing, and the appearance of the liquid form. The molecules, however, still retain a certain freedom of motion, but this is diminished with lowering of the temperature until at a certain stage the molecules form a tighter grouping, corresponding to the solid state where the freedom of motion of the individual molecules is much restricted. In order to account for the resistance of solids to compression or extension, it has been supposed that the force between molecules is attractive at large distances but repulsive at small distances. While we are able to offer a general explanation of the passage of an element from one state to another, a complete explanation of such phenomena will only be possible when we know the detailed structure of the atoms and the nature and magnitude of the forces between them.

While the kinetic theory of gases has proved very successful in explaining the fundamental properties of gases, its strength, and at the same time its weakness, lies in the fact that in most cases it is unnecessary for the explanation to know anything of the structure of the atom or molecule, or of the forces between them. In some investigations, in order to explain some of the more recondite properties of gases, assumptions have been made of definite laws of force between the molecules, but no very definite or certain results have so far been achieved in this direction. It should, however, be pointed out that the kinetic theory afforded us for the first time with a satisfactory method of estimating approximately the dimensions of molecules and the actual number in a given weight of matter. As the recent development of science has provided us with more certain methods of estimation of these important quantities, we shall not enter further into the question at present.

Crystals

There is another very striking form that matter sometimes assumes, which has always attracted much attention and which has recently emerged into much prominence. It is well known that the majority of substances under suitable conditions form crystals of definite geometrical form, which is characteristic of the particular atoms or groups of atoms. The great variety of crystal forms that are known have all been classified as belonging to one or more of the 230 forms of point symmetry which are theoretically possible. While considerations of symmetry are a sufficient guide to the classification of crystals, they offer no explanation of the definite architecture of the crystal nor of the nature of the forces that cause the atoms or molecules to arrange themselves in such definite geometric patterns. We are inevitably led

to the conclusion that the atoms of the crystal are arranged according to a definite system, which is characteristic of the particular crystalline form, and the unit of structure is repeated indefinitely with continued growth of the crystal. In fact, if we had no other evidence, the crystalline form of matter would itself point to the necessity of an atomic structure of matter. While many attempts have been made to explain the grouping of the atoms in a crystal, there has been on the whole little success with the exception, possibly, of Pope and Barlow's theory that the atoms take up the positions of closest packing, the dimensions assigned to the atom depending on a quantity connected with its chemical valency. It is only within the last year that a new and powerful method of attack of this problem has been developed, largely through the experiments of Professor Bragg and his son, W. L. Bragg. On account of the definite ordering of the atoms in a crystal, it acts like an almost perfect optical grating, only in three dimensions, where the grating space is exceedingly small—in most cases about one hundred millionth of a centimeter. Laue showed that when Röntgen rays passed through a crystal, definite interference patterns were observed. This result was of great importance, as it showed that Röntgen rays must consist of very short transverse waves akin to those of light. Bragg showed that the reflection, or rather diffraction, of Röntgen rays incident on the face of a crystal, afforded a very simple method of determining the wave length of the bright lines generally present in an X-ray spectrum. By a study of the position and intensity of the spectra

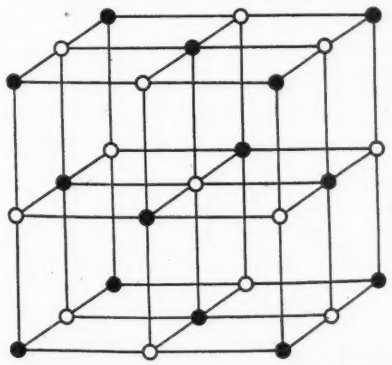

FIG. 1. ARRANGEMENT OF ATOMS IN A ROCK SALT (NaCl) CRYSTAL, WHITE CIRCLES REPRESENT SODIUM ATOMS, BLACK CHLORINE.

in different orders thrown by the crystal, it was possible to examine in detail the structure of the crystal, and to deduce the grating space, *i. e.*, the distance between successive planes of atoms. The subject is so large and the discovery of this method so recent, that so far only a few of the typical crystals have been examined, but in these cases we are able to obtain most positive evidence of the grouping of the atoms in the crystal. The results indicate that the atom and not the mole-

cule is the unit of the crystal structure. Consider the structure of the simple cubic crystal of rock salt (sodium chloride). The structure of the crystal deduced by Bragg is shown in Fig. 1. The sodium atoms are marked by black spheres, the chlorine atoms by white spheres. The simplicity of the crystal architecture is obvious, for all the atoms are equi-distant. The structure of the diamond is more complicated but it is one of great interest, for all the atoms in these cases are of one kind, carbon. The structure found by Bragg is seen in Fig. 2*A*.

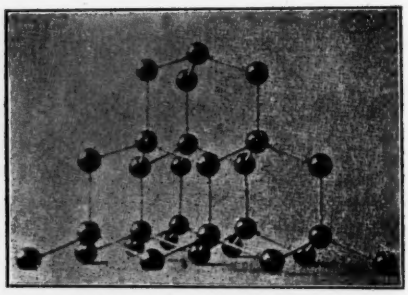

FIG. 2a. ARRANGEMENT OF CARBON ATOMS IN A DIAMOND.

The atoms are all equi-distant, but the general arrangement differs markedly from that of rock salt. It is seen that each carbon atom is linked with four neighbors in a perfectly symmetrical way, while the linking of six carbon atoms in a ring is also obvious from the figure. The distance between the planes containing atoms is seen to alternate in the ratio 1 : 3. This variation of the grating space is brought out clearly

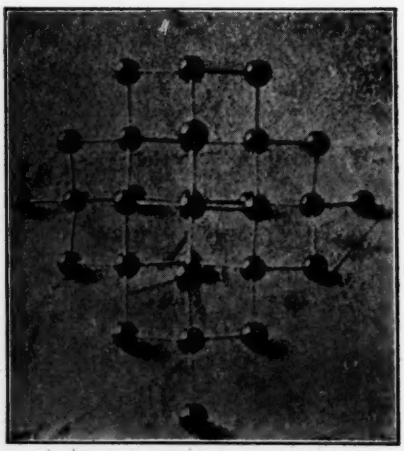

FIG. 2b. CUBICAL ARRANGEMENT OF CARBON ATOMS IN A DIAMOND.

from the study of the spectra, and is an essential feature of the structure of the diamond. The cubical arrangement is shown by turning the model so that the lines joining the atoms are vertical and horizontal (see Fig. 2*B*).

Now that we have a method of determining the arrangement and distances apart of the atoms in a crystal, the next step will be to examine the intensity and type of forces which are brought into play to keep the atoms in equilibrium and relatively fixed in their places. It is to be expected that the atoms are able to move to and fro about their position of equilibrium, and this is indicated by the effect of lowering the temperature of the crystal; for the intensity of the diffraction spectra increases as the amplitude of motion of the atom diminishes. The sharpness of the diffraction spectra suggests that the atoms are not only arranged at definite distances from one another but that each atom is orientated in a definite position with regard to its neighbor.

While varieties of crystals are known of all degrees of hardness, the work of Lehmann has brought to light the unexpected existence of crystalline arrangement in some liquids. These liquid crystals are best shown in certain complex organic substances at a temperature slightly above their melting point, and they are only observable in the liquid by the patterns and colors developed when polarized light passes through them. These crystals are mobile like a drop of oil in a solution and can be squeezed into a variety of patterns. Such results would indicate that the molecules of the liquid have a tendency to arrange themselves in ordered patterns, although it is difficult to understand how the freedom of relative motion that is supposed to characterize a liquid can contemporaneously exist with an ordered arrangement of some of the constituent molecules.

Light Spectra

We will now direct our attention to another type of phenomenon which ultimately promises to throw much light on the detailed structure of the atom. When the light from an incandescent vapor or gas is passed through a prism or reflected from a grating, it is resolved and gives a characteristic spectrum consisting of a number of bright lines. By suitable methods, the wave-length of these radiations can be determined with great accuracy. Each of these lines represents a definite and characteristic mode of vibration of the atom, and from the exceeding complexity of the spectra of many of the heavy elements, we are forced to conclude that an atom can vibrate in a great variety of ways. When the meaning of the dark lines in the solar spectrum was correctly interpreted, we were enabled at one stride to extend our methods of observation to the sun and the furthest fixed stars. It was soon recognized that atoms of the same element always vibrated the same way under all conditions. It was found, for example, that hydrogen atoms in the earth vibrated in exactly the same way as the same atoms in a distant star. The important bearing of this result on the structure of atoms was pointed out by Clerk Maxwell in his well-known address on "Atoms

and Molecules" before the British Association at Bradford in 1873, from which it is interesting to quote the following.

> In the heavens we discover by their light, and by their light alone, stars so distant from each other that no material thing can ever have passed from one to another; and yet this light, which is to us, the sole evidence of the existence of these distant worlds, tells us also that each of them is built up of molecules of the same kinds as those which we find on earth. A molecule of hydrogen, for example, whether in Sirius or in Arcturus, executes its vibrations in precisely the same time.
>
> Each molecule[1] therefore throughout the universe bears impressed upon it the stamp of a metric system as distinctly as does the metre of the Archives at Paris, or the double royal cubit of the temple of Karnac.
>
> No theory of evolution can be formed to account for the similarity of molecules, for evolution necessarily implies continuous change, and the molecule is incapable of growth or decay, of generation or destruction.
>
> None of the processes of nature, since the time when nature began, have produced the slightest difference in the properties of any molecule. We are therefore unable to ascribe either the existence of the molecules or the identity of their properties to any of the causes which we call natural.
>
> On the other hand, the exact equality of each molecule to all others of the same kind gives it, as Sir John Herschel has well said, the essential character of a manufactured article, and precludes the idea of its being eternal and self-existent.

While there is no doubt that an atom of an element in the earth or in a star vibrates in identical fashion under the same physical conditions, it is now known that the frequency of vibration of an element is not the exact constant that was at first supposed. It is altered to a slight extent by motion of the source, by change of pressure, and by the application of magnetic and electric fields. The apparent change of frequency of vibration with the motion of the source relative to the observer has proved an invaluable method for studying the motion of stars in the line of sight, while the displacement of the lines of hydrogen in the sun has in the hands of Professor Hale and his assistants proved of great power in throwing light on some of the physical conditions that exist in that distant body. It has been found that there is order and system in the great complex of modes of vibration of an atom, and that many of the lines can be arranged in definite series whose rates of vibration are connected by simple and definite laws. It is only within the last year or two that we have been able to form some idea of the origin of these spectra and the meaning of a spectral series. The fact that the lightest and presumably the simplest atom known, viz., hydrogen, gives a very complicated light spectrum was at first, and quite naturally, believed to indicate that the hydrogen atom must be a very complex structure. We shall see later, however, that the hydrogen atom is believed to have an exceedingly simple structure, and that the complexity of the spectrum is to be ascribed rather to a complexity in the laws of radiation.

[1] Maxwell used the term "molecule" where we now use the term "atom."

We have seen that the study of the spectrum led Maxwell to conclude not only that the atoms were identical in weight and form but that they were the only permanent and indestructible units in this changing world. The apparent identity of the spectrum under all conditions certainly strongly supported such a view at that time. It was believed that if some of the atoms were changing, it would be shown by a *gradual* alteration of their modes of vibration, *i. e.*, of the spectrum. It was left to the beginning of this century to show the fallacy in this deduction, and to bring undoubted evidence that some elements at least are undergoing spontaneous transformation with the appearance of new types of matter giving a new and characteristic spectrum. This question will be discussed later in some detail.

Electrons

Before, however, considering the bearing of radioactive phenomena on the structure of the atom, I must refer to a discovery which has exercised a most profound influence on the development of physics in general and on our ideas of the structure of atoms. Sir William Crookes long ago found that when an electric discharge was passed through a vacuum tube at very low pressures, a peculiar type of radiation appeared, known as the "cathode rays." This radiation appeared to be projected from the cathode in straight lines, and, unlike light, was deflected by a magnet. These rays excited strong phosphorescence in many substances in which they fell, and also produced marked heating effects. Crookes concluded that the cathode rays consisted of a stream of negatively charged particles moving at high speed. The general properties of this radiation appeared so remarkable that Crookes concluded that the material constituting the cathode stream corresponded to a "new or fourth state of matter." After a controversy extending over twenty years, the true nature of these rays was finally independently shown in 1897 by the experiments of Weichert and Sir J. J. Thomson. They proved, as Crookes had surmised, that the rays consisted of a stream of negatively charged particles travelling with enormous velocities from 10,000 to 100,000 miles a second, depending on the potential applied to the vacuum tube. In addition, it was found that the mass of the particle was exceedingly small, about 1/1800 of the mass of the hydrogen atom—the lightest atom known to science. These results were soon confirmed and widely extended. These corpuscles, or electrons, as they are now termed, were found to be liberated from matter not only in an electric discharge but by a variety of other agencies; for example, from a metal on which ultra-violet light falls, and also in enormous numbers from an incandescent body. Radium and other radioactive substances were found to emit them spontaneously at much greater speeds than those observed in a vacuum tube. It thus appeared that the electrons must be a constituent of the atoms of mat-

ter and could be released from the atom by a variety of agencies. This idea was much widened and strengthened by the investigations of Zeeman and Lorentz, who showed that the radiation of light must be mainly ascribed to the movements of electrons of the same small mass within the atom.

It does not fall within the scope of my address to outline the very important consequences that followed in many directions from this fundamental discovery of the independent existence of the electron and its connection with matter. It was found by Kaufmann that the mass of the electron was not a constant but increased with its speed, and from this result it was deduced that the electron was an atom of disembodied or condensed electricity occupying an exceedingly small volume, whose mass was entirely electrical in origin.

Unit of Electricity

I should mention here one important consequence that has followed from these discoveries. From the laws which control the passage of electricity in conducting solutions, Faraday recognized that there must be a close connection between the atom of matter and its electrical charge. Maxwell and Helmholtz suggested that the results were simply explained by supposing that electricity was atomic in nature. This conclusion is now definitely established, and the positive charge carried by the hydrogen atoms in the electrolysis of water is believed to be the fundamental unit of electrical charge. This charge is equal to and opposite to the charge carried by the electron. Any charge of electricity, however small or large, must be expressed by an integral multiple of this fundamental unit of electricity. The actual value of this unit charge has been measured by a great variety of methods and with concordant results. One of the most detailed and accurate investigations of this important constant has been made by Professor Millikan, of the University of Chicago.

Objections to the Atomic Theory

We have so far implicitly assumed that the great majority of scientific men now regard the atomic theory not only as a working hypothesis of great value but as affording a correct description of one stage of the sub-division of matter. While this is undoubtedly the case to-day, it is of interest to recall that less than twenty years ago there was a revolt by a limited number of scientific men against the domination of the atomic theory in chemistry. The followers of this school considered that the atomic theory should be regarded as a hypothesis, which was of necessity unverifiable by direct experiment and should, therefore, not be employed as a basis of explanation of chemistry. This point of view was much strengthened by the recognition of the power of thermodynamics in affording a quantitative explanation of the

changes of energy in chemical reactions without the assumption of any definite theory of the constitution of matter. This tendency advanced so far that text-books of chemistry were written in which the word atom or molecule was taboo, and chemistry was based instead on the law of combination in multiple proportion. At that time, it did undoubtedly appear that there was little, if any, hope of finding a concrete proof of the validity of the atomic hypothesis, or of detecting by its effects a single atom of matter or a single electron, for it was known that the smallest fragment of matter visible under a high power microscope must still contain many millions, or even billions, of atoms.

The march of science has, however, been so rapid in this direction that we have been able in recent years to show in a definite and concrete way the independent existence of atoms and also of electrons in rapid motion.

Counting Atoms and Electrons

We shall first of all consider the method devised by Rutherford and Geiger for detecting and recording the effects of single alpha particles from radium. At this stage, it is unnecessary to enter into details of the nature of the transformations occurring in radioactive matter. It suffices to say here that the atoms of a radioactive substance are unstable and occasionally break up with explosive violence. In many cases, the explosion is accompanied by the ejection of a charged body, called the alpha particle, with a velocity of about 10,000 miles a second. These alpha particles are known from other investigations to consist of charged atoms of the rare gas helium. The presence of these rays is simply shown by the marked phosphorescence they set up in certain substances. I have here a fine glass tube which was filled about a week ago in Manchester with purified emanation released from about one fifth of a gram of pure radium. In the interval of its journey across the Atlantic, the activity of the emanation has decayed to about one quarter of its original value. The glass walls of the tube are made so thin—about 1/100 millimeter—that the alpha rays are able to escape freely into the surrounding air. They produce a small phosphorescence in the walls of the glass tube which is just visible in the darkened room. On bringing near, however, a screen covered with zinc sulphide, a brilliant phosphorescence is observed which increases in intensity as we approach the tube. Similar effects are seen to be produced in this crystal of willemite, while the crystal of kunzite is seen to be translucent and emit a ruddy light. This phosphorescence of zinc sulphide and willemite is due mainly to the alpha rays, and from the present emanation tube about 5,000,000,000 of these particles are projected each second.

In their passage through air or other gas, the alpha particles produce from the neutral molecules a large number of negatively charged

particles called ions. The ionization due to the alpha particles can be readily measured by electrical methods, and it can be shown that the effect to be expected from a single alpha particle is much too small to detect except by very refined methods. In order to overcome this difficulty, Rutherford and Geiger employed a method of magnifying automatically several thousand times the electric effect due to an alpha

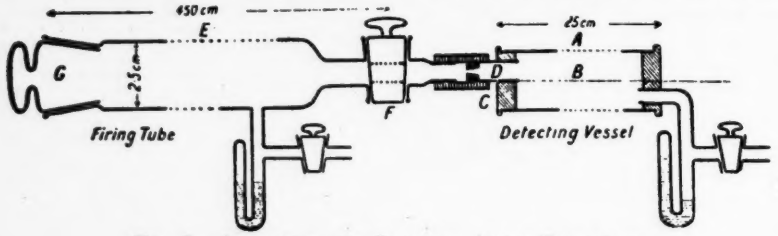

FIG. 3. APPARATUS FOR COUNTING ALPHA PARTICLES.

particle. The general arrangement of the original apparatus is seen in Fig. 3.

A few of the alpha rays from a radioactive substance passed along an exhausted tube *E* through an opening *D* covered with thin mica into the detecting tube *AB*. The latter contained a central insulated electrode *B* connected with an electrometer, and the pressure of the gas inside was adjusted to a few centimeters of mercury. The tube *B* was connected with the negative pole of a battery of about 1,500 volts, the other pole being earthen. The potential was adjusted so that a spark was on the point of passing between *A* and *B*. Under such conditions, the ionization due to an alpha particle passing along the detecting vessel is magnified several thousand times by collision of the negative and positive ions with the neutral molecules.

The entrance of an alpha particle into the detecting vessel is then signified by a sudden *ballistic* throw of the electrometer needle, and the number of particles entering the vessel in a given time can be counted by observing the throws. The amount of active matter and its distance from the opening were adjusted so that three to five alpha particles entered the opening per minute. The following table illustrates the results obtained:

	Number of Throws	Magnitude of Successive Throws, Scale Divisions
1st minute	4	11, 12, 10, 11
2d minute	3	10, 11, 8
3d minute	5	10, 9, 13, 8, 12
4th minute	4	18*, 8, 12
5th minute	3	10, 6, 10
6th minute	4	9, 10, 12, 11
7th minute	2	10, 11
8th minute	3	11, 13, 8
9th minute	4	8, 20*
10th minute	3	8, 12, 14, 6
Average per minute, 3.5.	Average throw, 10 divisions.	

It will be seen that the number of throws varies from minute to minute. This is to be expected since the chance of an alpha particle entering the opening is governed by the ordinary laws of probability. It will be seen that two throws, marked by asterisks, are much larger than the others. These were due to the passage of two alpha particles through the opening within a short interval. This was readily seen from the motion of the spot of light reflected from the electrometer needle. As the needle was moving slowly near the end of its swing caused by one alpha particle, a second impulse due to the entrance of another was communicated to it.

By this method, the number of alpha particles expelled from one gram of radium per second was determined. Of course only a minute fraction of the alpha particles was actually counted, but the total number was deduced on the assumption, verified by experiment, that the alpha particles on an average were expelled equally in all directions. In this way, one gram of radium in equilibrium was found to expel the enormous number of 1.36×10^{11} alpha particles each second.

Another interesting result followed from these experiments. It has long been known that the alpha particles produce a marked phosphorescence in crystalline zinc sulphide. When examined by a lens, the light is found not to be uniform but exhibits a very beautiful scintillating effect. By counting the number of scintillations due to the alpha particles, it was found that each scintillation was produced by the impact of a single alpha particle. It is thus seen that two distinct methods, one electrical and the other optical, are available for detecting and counting single alpha particles, *i. e.*, single atoms of matter. This is only possible because the atoms are in swift motion and expend their great energy of motion in ionizing the gas or in producing luminosity in zinc sulphide.

Still another simple method was devised later. Kinoshita first showed that a single alpha particle produced a detectable effect on a photographic plate which was observable under a microscope. A number of experiments have been made by Reinganum, Makower, and Kinoshita to examine the effect of single alpha particles on a photographic plate. If a fine needle point coated with a trace of radioactive matter rests on the surface of the film, the plate on development shows a number of distinct trails radiating from the active point. Each of these trails results from the action of a single alpha particle. A beautiful photograph of this kind (magnification about 300) obtained by Kinoshita is shown in Fig. 4. It appears that each alpha particle makes a certain number of the grains, through which it passes, capable of development.

The use of an ordinary electrometer is not very suitable for counting alpha particles by the electric method, since the time of swing of the electrometer needle is fairly long, and accurate counting can be made

when only a few alpha particles enter the detecting vessel per minute. This difficulty can be got over by the use of a string electrometer in

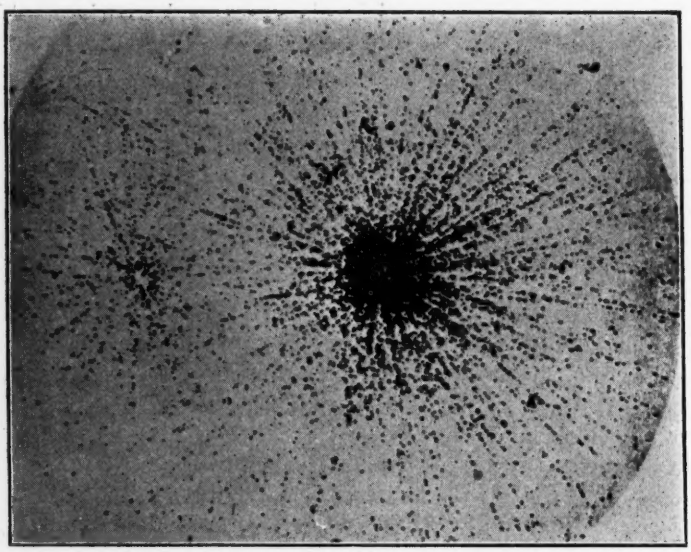

FIG. 4. PHOTOGRAPHIC EFFECT DUE TO ALPHA PARTICLES FROM A CENTRAL POINT.

which the moving system consists of a fine silvered quartz fiber suspended between two charged parallel plates and viewed with a high-power microscope. The entrance of an alpha particle is shown by a sudden movement of the fiber, and if the current is allowed to leak away through a suitable resistance, the fiber returns to the position of rest in a small fraction of a second. The movement of the fiber can be re-

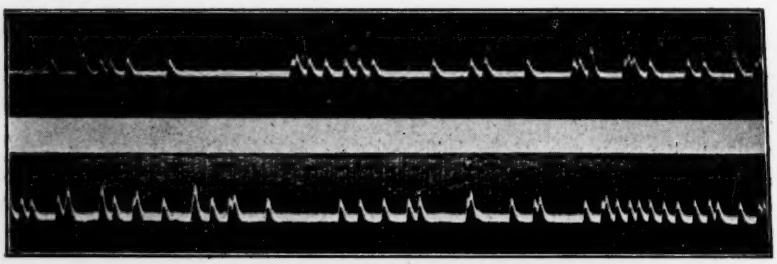

FIG. 5. PHOTOGRAPHIC RECORD ON STRING ELECTROMETER OF ENTRANCE OF ALPHA PARTICLES INTO THE DETECTING VESSEL.

corded photographically on a moving film, and it is possible in this way to count accurately the number of particles, even if several thousand enter the detecting vessel per minute.

Examples of such photographic records, obtained by Rutherford and Geiger, are shown in Fig. 5. The vertical movements of the fiber from the horizontal line are due to the entrance of alpha particles, and it is seen how clearly the detailed movements of the fiber are registered. In some cases, one alpha particle follows another so rapidly that the

fiber has not time to come to rest in between, and this is shown by the saw-like appearance of some of the peaks in the photograph. It will be noticed also that while the heights of most of the deflections are nearly the same, in a few cases the deflections are nearly twice as great as the normal. This is due to the nearly simultaneous entrance of two alpha particles into the vessel. Although the photographic film moved at a constant rate, it is seen that the throws due to the alpha particles are distributed very irregularly along it. A close examination of such records shows that variations of this kind are in accord with the ordinary laws of probability.

During this year, Dr. Geiger has found a still more sensitive detector for counting alpha particles. The arrangement, which is very simple, is shown in Fig. 6. A fine sharply pointed needle ends about

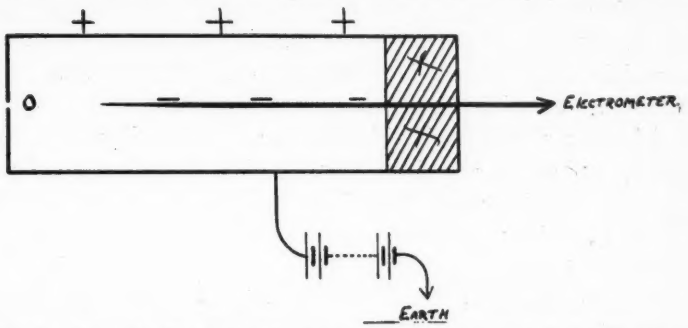

FIG. 6. GEIGER'S DETECTOR OF INDIVIDUAL ALPHA AND BETA PARTICLES.

one centimeter from the opening *O*, where the alpha particles enter. If the outer brass tube be charged positively to about 1,000 volts, and the needle connected with a string electrometer, it is found that the entrance of an alpha particle produces a very great deflection of the fiber. So sensitive is this method, that Geiger has found that individual beta particles can easily be detected and counted by its aid. This is very remarkable when it is remembered that the ionization effect

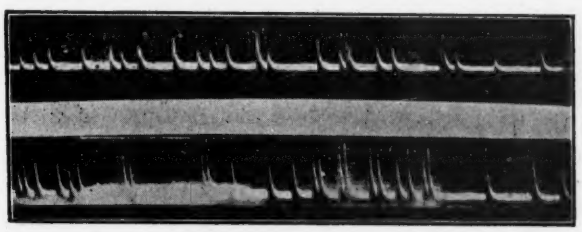

FIG. 7. RECORD WITH STRING ELECTROMETER, UPPER RECORD FOR BETA PARTICLES. LOWER FOR ALPHA PARTICLES.

due to a beta particle is on the average not more than 1/100 of that due to an alpha particle.

A photographic record of the entrance of beta particles into the detecting vessel is shown in Fig. 7. The upper record is for beta par-

ticles and the lower for alpha particles. I am indebted to Dr. Geiger for this photograph. It is seen that the effect of a beta particle is just as marked and as definite as for an alpha particle with the old form of detector. We are thus in a position not only to count single atoms of matter but also to detect the presence of a single electron in swift motion, although the mass of the latter is exceedingly small compared with that of the lightest atom.

I would now very briefly direct your attention to some results, which to my mind not only completely prove the hypothesis of the atomic structure of matter but allow us at once to calculate the number of atoms in a given weight of matter with the minimum amount of assumption. We have seen that by direct counting it has been found that 1.36×10^{11} alpha particles are expelled per second from one gram of radium in equilibrium with its rapidly changing products. Now it has been definitely shown, by methods I need not discuss here, that each alpha particle consists of a helium atom carrying two unit positive charges. Since the alpha particle, when it has lost its charge, becomes a neutral helium atom, we should expect to find that helium would be produced by radium at a definite rate. This is found to be the case, and it is not difficult to determine by actual measurement the volume of helium formed by a known quantity of radium in a given time. It has been found that one gram of radium in equilibrium produces each year 156 cubic millimeters of helium at standard pressure and temperature. Now the number of alpha particles expelled per year per gram is 4.29×10^{18}, giving rise to 156 cubic millimeters of helium; each of these alpha particles is an atom of helium, and consequently the number of atoms of helium in one cubic centimeter of that gas at normal pressure and temperature is 2.75×10^{19}.

It appears to me that no more direct and convincing proof could be obtained of the atomic structure of matter or of the number of atoms forming a given weight or volume of helium; for the number of separate constituents are counted and the volume of the resulting gas is measured. The value so obtained is in good accord with measurements based on entirely different data of various kinds.

It is somewhat remarkable that while the study of radioactive phenomena has clearly indicated that the atom is not always permanent and indestructible, it has at the same time supplied the most convincing proof of the actual reality of atoms, and has provided some of the most direct methods of determining the values of atomic magnitudes.

Tracks of Swift Atoms and Electrons

We have seen how it is possible to detect single alpha and beta particles and to count their number. We will next consider a most remarkable experimental method not only for detecting such particles but of following in detail the effects produced by them in their passage

through a gas. C. T. R. Wilson showed many years ago that the positively and negatively charged ions produced in a gas by the passage of alpha and beta and X rays possessed a remarkable property. When air, for example, saturated with water vapor is suddenly expanded, the air is rapidly cooled and the water tends to deposit on any nuclei present. C. T. R. Wilson showed that in dust-free air, the ions produced by external radiations become nuclei for the condensation of water upon them when the cooling by expansion was sufficiently great. Under such conditions, each ion becomes the center of a visible globule of water, and the number of drops formed is equal to the number of ions present.

C. T. R. Wilson later perfected this method to show the trail of a single alpha or beta particle in passing through the gas; for each of the

FIG. 8. TRACKS OF ALPHA PARTICLES FROM CENTRAL POINTS (C. T. R. WILSON'S METHOD).

ions produced by the flying particle becomes a visible drop of water by the sudden expansion. By suitable arrangements, the trails of the individual particle can be photographed, and the pictures obtained show with remarkable fidelity and detail the ionizing effects produced in the passage of alpha and beta particles or X rays through gases.

Fig. 8 shows the tracks of the alpha particles shot out from a small fragment of radium. The number of ions produced per centimeter in the gas by the alpha particle is so great that the trail of drops shows as a continuous line. The alpha particles are seen to radiate in straight lines from the active point, and have a definite range in air—a characteristic property discovered by Bragg many years ago. The next photograph (Fig. 9) shows a magnified image of these trails. It is seen that the tracks are generally quite straight, but in a few cases there is a sudden bend near the end. The significance and causes of these sudden deviations in the rectilinear paths of the alpha particles will be discussed later.

A radioactive substance like radium emits not only alpha particles but beta particles which are electrons in very swift motion. These beta particles are generally far more penetrating than the alpha rays, but produce a much smaller number of ions per centimeter of their path

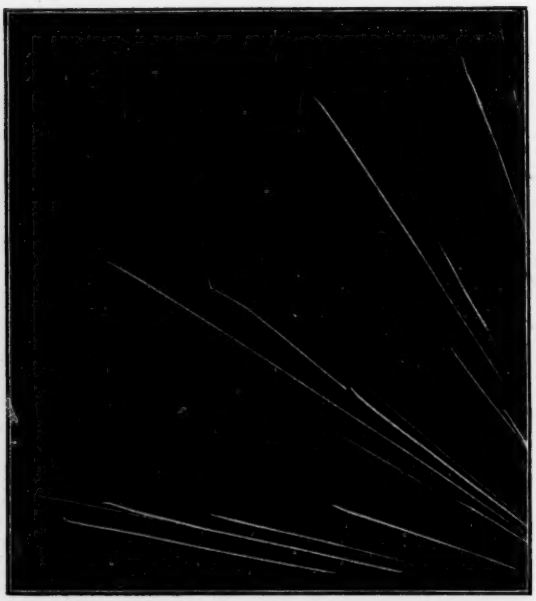

FIG. 9. MAGNIFIED TRACK OF ALPHA PARTICLES (WILSON).

through a gas. In Fig. 10 is seen the track of a swift beta particle crossing the expansion chamber. It will be observed that the path is not straight but tortuous, due to the marked scattering of the particle by collisions with the atoms of matter in its path. Although the trail

FIG. 10. TRACKS OF BETA PARTICLES.

is clearly defined, the density corresponding to the number of drops per centimeter is much smaller than for the alpha particle. In fact by magnifying still further small portions of the track, the individual ions, or rather the drop formed round each ion produced by the beta particle, are clearly visible. In this way, it is obviously possible to count directly the number of ions produced in any length of the path.

These beautiful photographs thus not only bring out clearly that alpha and beta particles are definite entities but show with great perfection the actual path of the particles in traversing matter. The next photograph (Fig. 11) shows the effect of passing a pencil of

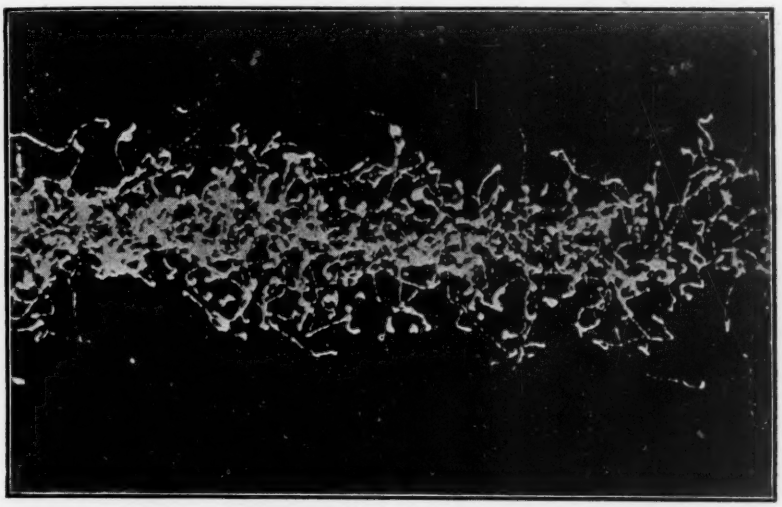

FIG. 11. BETA PARTICLES PRODUCED BY PASSAGE OF X-RAYS THROUGH AIR (WILSON).

Röntgen rays through the expansion chamber. It is believed that these rays do not ionize the gas directly but indirectly through the slow-speed electrons which are liberated by some of the atoms acted on by the radiation. These electrons are not nearly so swift as some of those emitted by radium, for they are only able to transverse a few millimeters of air before being stopped. The photograph brings out clearly these effects, and shows the tortuous path of a beta particle resulting from collisions with the atoms. Such scattering effects become more marked the slower the velocity of ejection of the beta particle.

TRANSFORMATION OF MATTER

While the discovery of the independent existence of the electron as a constituent of the structure of atoms gave a great impetus to the study of atomic structure, it was soon found that the removal or addition of an electron from an atom did not appear to cause a permanent transformation of the atom; for no evidence has yet been obtained that the passage of an electric current through a gas or metal is accompanied

by a permanent alteration of the atoms of matter through which the current passes, although there is little doubt the current is carried in part at least by the electrons liberated from the atoms.

The first definite evidence of the transformation of matter was obtained from a study of the processes occurring in radioactive substances. The writer and Mr. Soddy in 1903 put forward the theory that the radiations from active matter accompanied a veritable transformation of the atoms themselves. The correctness of this theory as an explanation of radioactive phenomena is now generally accepted. As an illustration of these processes, consider the transformation of the radioactive element uranium. The series of substances which arise from the transformation of uranium are shown clearly in the diagram (Fig. 12). The best known of these elements is radium, which will be

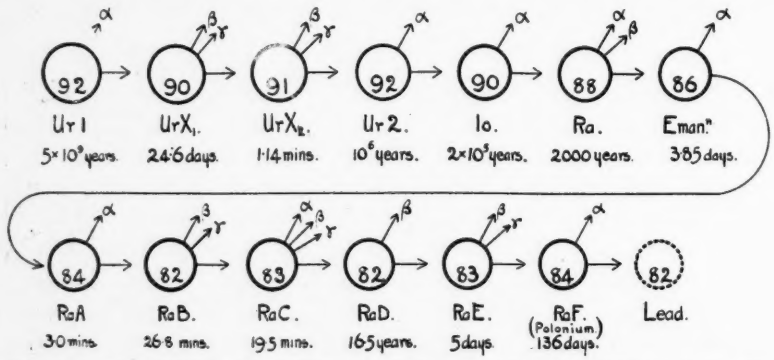

FIG. 12. SUCCESSIVE SUBSTANCES PRODUCED BY THE TRANSFORMATION OF THE URANIUM ATOM.

taken as a typical example of a radioactive substance. Radium differs from an ordinary element in its power of spontaneously expelling alpha particles with very great speed. This property is ascribed to an inherent instability which is not manifest in the atoms of ordinary elements. A small fraction of the radium atoms—about one in 100,000 million—break up each second with explosive violence expelling a fragment of the atom—the alpha particle—with very great speed. The residue of the atom is lighter than before and becomes the atom of an entirely new substance, which is called the radium emanation. The atoms of the latter are far more unstable than those of radium, for half of them break up in 3.85 days, while half of the radium atoms break up in about 2,000 years. After the loss of an alpha particle, an atom of the emanation changes into an atom of a new substance radium A, which behaves as a solid. Radium A is very unstable, half of it breaking up in 3 minutes with the emission of an alpha particle, and gives rise to radium B. The latter differs from the substances already mentioned in the nature of its radiation, for it emits only beta rays but no alpha rays. Notwithstanding this fact, it is transformed according to the same law as an alpha ray substance, and gives rise to an entirely distinct element,

radium C. In the transformation of the latter, not only are swift alpha rays emitted but also beta rays of great speed. There is some evidence, however, that the substance called radium C is complex, and that the alpha and beta rays arise from two distinct substances.

The successive substances arising from radium C are radium D, radium E and radium F. The two former, like radium B, emit only beta rays; the latter, known generally as polonium, emits only alpha rays. It is believed that the sequence of changes ends with the transformation of radium F, which is supposed to change into the well-known non-radioactive element lead.

According to the transformation theory radium, like all other radioactive products, must be regarded as a changing element, but one whose rate of transformation is very slow compared with its successive products. Boltwood showed experimentally that radium is half transformed in about 2,000 years, and a quantity of radium would practically have disappeared as such in 100,000 years. In order to account for the continued existence of radium in the earth, it is necessary to suppose that it is steadily produced from some other element. Boltwood showed that the parent substance is a radioactive element called ionium, which is itself derived from the transformation of uranium. A quantity of ionium, entirely freed from radium, will grow radium at a slow but constant rate. The primary element of the ionium-radium series is uranium, which we can calculate should be half transformed in 5,000 million years—a period probably long compared with the age of many of the minerals in which uranium is found.

The complete sequence of changes in the uranium-radium series is shown in the diagram. The nature of the radiation and the half period of transformation are added for each element. In addition to uranium, there are two other radioactive elements, thorium and actinium, which are transformed with the appearance of a number of new substances. The time at my disposal, however, is too short to discuss these changes in detail. Thorium is known to be a primary element whose radioactive life is even longer than uranium, but actinium is believed to be a branch descendant from some point of the uranium series, and is thus to be regarded as a product of that element. In all, thirty-four of these radioactive substances have been discovered, and the position of each in the three main radioactive series has been determined.

Each of these new substances is to be regarded as a distinct chemical element in the ordinary sense, but differs from ordinary stable elements in the spontaneous emission of special radiations which accompanies the disintegration of the atoms. The radioactive substances are thus transition elements which have a limited life and which carry within themselves the seeds of their own destruction. Not only are these transition elements distinguished by their types of radiation but also by

their distinct physical and chemical properties. The extraordinary differences in properties which sometimes exist between a product and its parent substance are well illustrated by the comparison of radium and its product, the emanation. Radium is a solid element of atomic weight 226, which has chemical properties allied to barium but is capable of separation from it. The emanation is a heavy monatomic gas of atomic weight 222, which by its absence of chemical properties is allied to the well known group of rare gases, helium, argon, neon, xenon and krypton. In some cases, the elements show almost identical physical and chemical properties with those of known elements, although they differ from them in their atomic weight and radioactivity. For example, radium B appears to be identical in ordinary chemical and physical properties with lead although its atomic weight, 214, is quite distinct from lead, 207. The probable explanation of this, at first sight, remarkable identity will be discussed later.

It is of interest to note that in the majority of cases a radioactive element breaks up in only one way which is characteristic for all the atoms of that element, and gives rise to only one new product. The work of Fajans and Marsden, however, has clearly shown that in the case of radium C and the corresponding products in the thorium and actinium series, the atoms break up in two distinct ways and give rise to two distinct radioactive elements. It has already been pointed out that actinium is in reality one of these side or branch products. It is supposed that uranium X breaks up in two distinct ways, the smaller fraction giving rise to actinium. The evidence, however, on this point, is not yet complete.

The radioactive elements are in some respects more interesting and important than stable elements, for, in addition to the ordinary physical and chemical properties, they possess the radioactive property which allows us to study the mode and rate of transformation of their atoms.

It may be asked what is the essential difference between radioactive changes and ordinary chemical changes. In the radioactive changes we are not dealing with the dissociation of molecules into atoms but an actual disruption of the chemical atom. The disintegration of any given element appears to be a spontaneous and uncontrollable process which, unlike ordinary chemical changes, is quite unaffected by the most drastic changes in temperature or by any other known physical or chemical agency.

The radioactive changes differ entirely from chemical changes not only in the peculiar character of the emitted radiations but also in the enormous emission of energy. It can be simply shown that the energy emitted from a radioactive substance which expels alpha particles is several million times greater than the energy emitted from an equal weight of matter in any known chemical reaction. This emission of energy is mainly to be ascribed to the conversion of the energy of

motion of the swift alpha and beta particles into heat, and is thus in a sense a secondary effect of the radiations. The enormous emission of energy is most simply illustrated by considering the case of the radium emanation together with its swiftly changing products, radium A, radium B and radium C. The heating effect of a given volume or weight of this gas has been accurately determined. From the data, it can be calculated that one pound weight of the emanation would emit heat energy initially at the rate of 23,000 horse power. The rate of emission decreases with the time, falling successively to half value after intervals of 3.85 days. During the life of the emanation the total energy emitted corresponds to an engine working at 128,000 horse power for one day. Such a quantity of emanation would be an enormously concentrated source of power, for the total energy emitted is many million times greater than for an equal weight of the most powerful known explosive.

The emission of energy from radioactive substances does not controvert the law of the conservation of energy; for the energy is derived from the atom itself where it exists in kinetic or potential form. We shall see later that the atom is believed to consist of a large number of positively and negatively charged particles which are collected in a very small volume and held together by intense electrical forces. Such an idea of atomic structure involves the necessity of a large store of energy resident in the individual atom. The great emission of energy from a radioactive substance like the emanation illustrates in a striking way the enormous reservoir of energy that must exist in the atoms themselves; for there is every reason to believe that an equivalent amount of energy is present in the atoms of the common heavy elements. This store of energy ordinarily does not manifest itself and is not available for use. It is only when there is a drastic rearrangement of the atom resulting from an atomic explosion that part of this store of energy is liberated.

It must be borne in mind that the processes occurring in radioactive matter are spontaneous and uncontrollable. There is at present no evidence to indicate that we shall be able in any way to influence radioactive changes. We are at present only able to watch and investigate this remarkable phenomenon of nature without any power of controlling it. In a recent book, H. G. Wells has discussed in an interesting way some of the future possibilities if this great reservoir of energy resident in the atoms were made available for the use of man. This will only be possible on a large scale if we are able in some way to alter the rate of radioactive change and to cause a substance like uranium, or thorium, to give out its energy in the course of a few hours or days instead of over a period of many thousands or millions of years. The possibility, however, of altering the rate of transformation of

radioactive matter, or of inducing similar effects in ordinary matter, does not at present seem at all promising.

Structure of the Atom

We have seen that in recent years a number of methods have been devised for determining with precision the actual weight of any atom of matter. If it be assumed that in the solid state the atoms, or molecules, of matter are in close contact, it is a simple matter to deduce the diameter of the atom. This varies slightly for different atoms, but on an average comes out to be about one hundred-millionth of a centimeter. It is necessary, however, to be cautious in speaking of the diameter of the atom. The term "diameter of the sphere of action" of the atom is preferable, for it is not at all certain that the actual atomic structure is nearly so extensive as the region through which the atomic forces are appreciable.

Even before the discovery of the electron, the general idea had been suggested that the atom was an electrical structure composed of negatively and positively charged particles held in equilibrium by electrical forces. Such ideas had been proposed and developed by Larmor and Lorentz in order to explain the electrical and optical properties of the atom. The proof that the negative electron was an independent unit of the structure of the atom gave a great impetus to the formation of more concrete ideas on atomic structure. There was one important difficulty, however, that arose at the outset. While negative electricity had been shown to exist in independent units of very small apparent mass, the corresponding unit of positive electricity was never found associated with a mass less than the atom of hydrogen. All attempts to show the existence of a positive electron of small mass, which is a counterpart of the negative electron, have resulted in failure, and it seems doubtful whether such a positive electron exists. The rôle played by positive electricity in the atom was thus a matter of conjecture. In a paper called "Æpinus Atomized," the late Lord Kelvin considered an atom to consist of a uniform sphere of positive electrification, throughout which negative electricity was distributed in the form of discrete electrons. In order to make such an atom electrically neutral, it is, of course, necessary that the positive charge should be equal and opposite to the charge carried by the electrons. This idea of the structure of the atom was taken up and developed with great mathematical skill by Sir J. J. Thomson. He investigated the constitution of atoms containing different numbers of electrons, and showed that such model atoms possessed properties very similar to those shown by the actual atoms. The Thomson atom proved for many years very useful in giving a concrete idea of the possible structure of the atom, and had the great advantage of being amenable to calculation.

The rapid advance of science in the last decade has provided us

with new and powerful methods of attack on this problem, and has allowed us to distinguish to some extent between various theories of atomic structure. One of these methods depends on the study of the deflection of swiftly moving bodies like alpha and beta particles in their passage through matter. It is found that these rays are always scattered in their passage through matter, *i. e.*, a narrow pencil of rays opens out into a diffuse or scattered beam. The alpha and beta particles move so swiftly that they are actually able to pass through the structure of the atom and are deflected by the intense forces within the atom. Geiger first drew attention to a very unexpected effect with alpha particles. When a pencil of alpha rays falls on a thin film of gold, for example, the great majority of the particles pass through with little absorption. A few, however, are found to be so scattered that they are turned back through an angle of more than a right angle. Taking into consideration the great energy of motion of the alpha particle, such a result is as surprising as it would be to a gunner if an occasional shot at a light target was deflected back towards the gun. It was found that these large deflections must result from an encounter with a single atom. The occasional sudden deflection of an alpha particle is well illustrated in one of the later photographs of the trail of an alpha particle obtained by Mr. C. T. R. Wilson, and shown in Fig. 13. It is

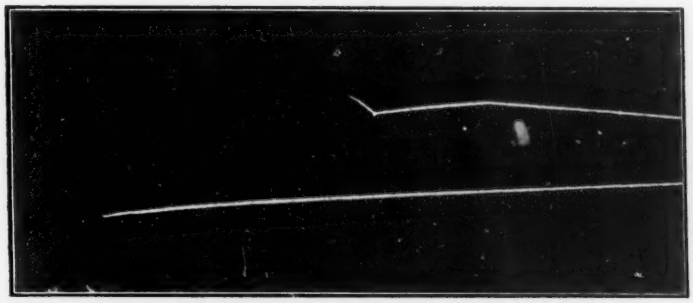

FIG. 13. TRACK OF ALPHA PARTICLES SHOWING SHARP DEVIATIONS (WILSON).

seen that the rectilinear path of the particle suffers two sharp bends, no doubt resulting in each case from a single close encounter with an atom. In the sharp bend near the end a slight spur is seen, indicating that the atom was set in such swift motion by the encounter with the alpha particle that it was able to ionize gas at a short distance. If the forces causing the deflection were electrical, it was at once evident that the electric field within the atom must be exceedingly intense. The distribution of positive electricity assumed in the Thomson atom was much too diffuse to produce the intense fields required. To overcome this difficulty, the writer inverted the rôle of positive electricity. Instead of being distributed through a sphere comparable in size with the sphere of action of the atom, the positive electricity is supposed to be

concentrated in a very minute volume or nucleus, and the greater part of the mass of the atom is supposed to be resident in this nucleus. The latter is supposed to be surrounded by a distribution of negative electrons extending over a distance comparable with the diameter of the atom as ordinarily understood. On this point of view, the alpha particle is the minute nucleus of the helium atom, which has lost its two external electrons. In this type of atom, the large deviations of the alpha particle take place when it passes through the intense electric field close to the nucleus of the colliding atom. The nearer it passes to the nucleus, the greater the deflection of the particle. Assuming that the forces between the alpha particle and the nucleus of the colliding atom are mainly electrical and vary according to an inverse square law, the alpha particle describes a hyperbolic orbit round the nucleus, and the relative number of alpha particles deflected through different angles can be simply calculated.

It was thus possible to test this theory of atomic structure by actual experiment. This was undertaken by Geiger and Marsden in a very important but difficult investigation. They examined the relative number of alpha particles scattered through various angles by their passage through thin films of matter, *e. g.*, aluminium, silver and gold, by actually counting the alpha particles by means of the scintillations on a zinc sulphide screen. The experimental results were found to be in very good accord with the theory, while Darwin, in addition, showed that any other law of force except the inverse square was incompatible with the observations.

From these results, it is a simple matter to show that the radium of the nucleus of the gold atom can not be greater than 3×10^{-12} cm.—an exceedingly small distance and only about one ten-thousandth part of the diameter of the atom. While the results thus indicated that the nucleus of a heavy atom was of minute dimensions, it was of interest to see whether a still lower limit could be obtained for lighter atoms. On the theory, the helium atom has a nucleus of two unit positive charges, and the lighter atom, hydrogen, should have a nucleus of only one unit. When an alpha particle passes through hydrogen gas, there should be occasional very close encounters between the particle and nucleus of the hydrogen atom. Since the mass of the hydrogen atom is only one quarter of that of helium, it is to be anticipated that the former should be set in very swift motion by a close collision with an alpha particle, and in special cases should be given a velocity 1.6 times greater than that of the colliding alpha particle, and should travel four times as far. Such swiftly moving hydrogen nuclei were actually observed by Marsden with the scintillation method when a pencil of alpha rays passed through hydrogen, and they were found to travel, as the theory predicted, about four times further than the alpha particle itself. Since the energy gained by the hydrogen nucleus depends on the closeness

of its approach to the alpha particle, it can be simply calculated that the centers of the nuclei must have passed within 10^{-13} cm. of each other. This is an extraordinarily small distance, even smaller than the diameter of the electron itself. It is thus clear that the nuclei of hydrogen and of helium must be exceedingly minute. It should be borne in mind that such observations only give a *maximum* limit to the size of the nucleus, and there is no experimental evidence against the view that the nucleus of the hydrogen atom may not actually prove to be minute in volume compared even with the negative electron. If this be the case, it appears probable that the hydrogen nucleus is the *positive electron* and that its great mass compared with the negative electron is due to the greater concentration of its charge. According to modern theory, the electrical mass of a charged particle varies inversely as its radius. The greater mass of the positive than of the negative electron would thus be explained if its radius were only 1/1800 of that of the negative electron, viz., about 10^{-16} cm.

There is no evidence to contradict this point of view, and its simplicity has much to commend it. In viewing the essential differences exhibited by positive and negative electricity in connection with matter and the obvious asymmetry of the distribution of the two electricities in the atom, one is driven to the conclusion that there is a fundamental distinction between positive and negative electricity. Since the unit of positive charge is identical in magnitude with the unit of negative charge, the only possible difference is the mass of the two units, and this on modern views is mainly dependent on the dimensions or degree of concentration of the electricity in these fundamental entities.

If we take the view that the hydrogen nucleus is the positive electron, it is to be anticipated that the nuclei of all atoms are built up of positive and negative electrons, the positive electricity being always in excess, so that the nucleus shows a resultant positive charge. The mass of the atom will depend mainly on the number of the massive positive electrons in the nucleus, although it will be affected to a slight extent by the number of the lighter negative electrons involved in the structure of the whole atom. The mass of the atom will no doubt be influenced also by the distribution of the positive and negative electrons in the nucleus, for these must be packed so closely together that their field must interact. As Lorentz has shown, the mass of a number of closely packed electrons is not necessarily the same as the sum of individual masses of the component electrons. Taking such factors into account, we should not necessarily expect the mass of all atoms to be nearly an integral multiple of the mass of the hydrogen atom, although it is known that in a number of cases such a relation appears to hold fairly closely.

The appearance of a helium atom in such a fundamental process as the transformation of radioactive atoms indicates that helium is one

of the units, possibly secondary, of which the nuclei of the heavy atoms are built up. In course of its successive transformations, a uranium atom loses eight helium atoms, a thorium atom six, and an atom of actinium five. The probability that helium is one of the units of atomic structure not only in the case of radioactive atoms but for ordinary atoms is strengthened by the fact that the atomic weights of a number of elements differ by about four units.

The fact that the helium nucleus survives the intense disturbance resulting in its violent ejection from a radioactive atom suggests that it is a very stable configuration. On the views discussed, it is natural to suppose that the helium nucleus of atomic weight about four is made up of four positive electrons united with two negative electrons. No doubt it is difficult to understand why such a system should hold together, but it must be remembered that we have no information as to the nature of magnitude of the forces existing at such minute distances as are involved in the structure of the nucleus.

We have so far assumed without proof that while the nucleus of an atom carries a resultant positive charge, negative electrons are also present. The main evidence on this point comes from a study of the radioactive elements. A substance which breaks up with the emission of swift electrons (beta rays), but no alpha particles, suffers disintegration according to the same laws and gives rise to a new element in the same way as when an alpha particle is lost. It seems necessary to suppose from a number of lines of evidence that a transformation which is accompanied by the emission of primary beta particles must have its origin in the ejection of a negative electron from the nucleus itself, or from a point very close to the nucleus.

There are no means at present of deciding definitely the relative number of positive and negative units composing the nucleus, except possibly from a consideration of the atomic weight of the atom in terms of hydrogen. It is, however, premature to discuss such questions until more information is obtained as to the structure of the nucleus and the effect of concentration and distribution of the component electrical charges on its apparent mass.

Charge Carried by the Nucleus

We are now in a position to consider a very important question, viz., the magnitude of the positive charge carried by the atomic nucleus. Since an atom is electrically neutral, the negative charge carried by the exterior distribution of electrons in the structure of the atom must be equal and opposite to the resultant positive charge carried by the nucleus. The electrical charge is most conveniently expressed in terms of the number of the fundamental units of charge in the nucleus. Since the charge carried by the electron is one unit, the charge on the nucleus of the atom may be expressed numerically by the number

of electrons exterior to the nucleus. Several methods of attack on this problem have been suggested. Sir J. J. Thomson showed that the scattering of Röntgen rays in passing through the atoms of matter must depend on the number of electrons composing the atom. By assuming that each electron scattered is an independent unit, an expression for the scattering was found in terms of the number of electrons in the atom. By comparison of the theory with experiment, Barkla deduced that for many elements the number of electrons in an atom was approximately proportional to its atomic weight and numerically equal to about one half of the atomic weight in terms of hydrogen.

The charge in the nucleus can also be directly determined from the experiments on scattering of alpha rays, to which attention has previously been drawn. Geiger and Marsden found that the large angle scattering of alpha rays in passing through different substances was proportional per atom to the square of its atomic weight. This showed that the positive charge on the nucleus was approximately proportional to the atomic weight at any rate for elements of atomic weight varying between aluminium and gold. By measuring the fraction of the total number of alpha particles which were deflected through a definite angle in passing through a known thickness of matter, the charge on the nucleus was deduced directly. The number of positive units of charge on the nucleus, which is equal to the number of external negative electrons, was found to be expressed by about one half of the atomic weight in terms of hydrogen. The results obtained by two entirely distinct methods of attack are thus in good accord and give approximately the magnitude of this important atomic constant.

It is obvious, however, that the deduction that the number of units of charge on the nucleus is half the atomic weight, must be only a first approximation to the truth even in the case of the heavier atoms. It has already been pointed out that the nucleus of the helium atom of atomic mass four must carry two unit charges, for it is difficult to believe that any of the exterior electrons of helium can remain attached after its violent expulsion from the atom and its subsequent passage through matter. If this be the case, the nucleus of the hydrogen atom of atomic mass one, must carry one unit charge. Van den Broek and Bohr have suggested that the charge on the nucleus might be equal to the actual number of the element when all the known elements are arranged in order of increasing atomic weight. This is in excellent accord with the experiments of scattering and removes a difficulty in regard to the lighter atoms. Taking this view, the nucleus charge is for hydrogen 1, helium 2, lithium 3, carbon 6, oxygen 8, etc. The simplicity of this conception has much to commend it.

During the last year a new and powerful method of attack on this fundamental problem has been developed by Moseley by the study of X-ray spectra. In 1912, Laue found that X rays showed obvious in-

terference or diffraction effects in their passage through crystals, thus proving definitely that the X rays consist of very short waves analogous to those of light. W. H. Bragg and W. L. Bragg and Moseley and Darwin found that the reflection of the X rays from crystals provided a very simple method of measuring the wave length of the X rays when the spacing of the atoms in the crystal is known. If the X rays give a spectrum containing some bright lines, the wave-lengths of the latter can be simply determined. The work of Barkla has shown us that an X radiation, characteristic of each element, is excited under certain conditions when X rays fall upon it. The penetrating power of this characteristic radiation increases rapidly with the atomic weight of the radiator. In heavy elements, another type of characteristic radiation makes its appearance. These two types of characteristic radiation have been called by Barkla the "K" and "L" radiations respectively. These radiations can be excited either by X rays of suitable penetrating power or by direct bombardment of the element by cathode rays in a vacuum tube. Moseley made a systematic examination of the X-ray spectra of a great majority of the elements. For this purpose,

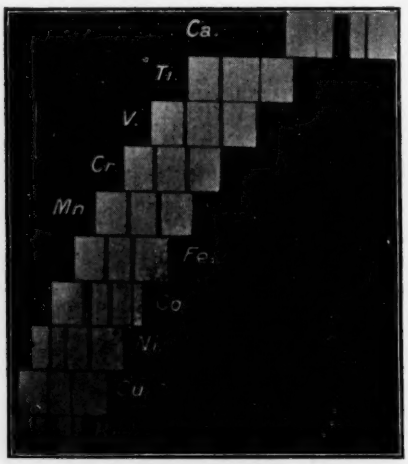

FIG. 14. X-RAY SPECTRA OF SUCCESSIVE ELEMENTS (MOSELEY). The additional lines in spectrum of Co and Ni are due to impurity. Brass shows the combined spectra of copper and zinc.

the elements examined were bombarded by cathode rays, and the spectrum of the radiation examined by reflection from a suitable crystal. He found that the spectra of the "K" radiation from elements varying in atomic weight from aluminium to silver were all similar in type, consisting mainly of two strong lines.[2] An example of the spectrum obtained for a number of successive elements is shown in Fig. 14. It is seen that with increasing atomic weight, the wave-lengths of the corresponding lines diminish, not irregularly but by definite and well marked

[2] In later work Rawlinson and Bragg have found that each of these lines is in reality a very close double.

steps. Moseley found that for the K radiation the frequency of the radiation was proportional to $(N\text{-}a)^2$ where N was a whole number which varied by unity in passing from one element to the next of higher atomic weight and a constant about unity. From silver to gold, the spectra given by the L radiations of elements were compared. These spectra consist of about five lines, of which two are relatively very strong. It was found again that the spectra were similar in type and that the frequency of a given line diminished by definite steps in passing from one element to another. The frequency of the radiation in this case was proportional to $(N\text{-}b)^2$ where b was a constant and N a whole number. Moseley concluded that the value of N in these expressions was the *atomic number, i. e.,* the number of the element arranged in order of increasing atomic weight. Taking aluminium as the 13th element, he found that succeeding elements were expressed by the value of N 14, 15, 16, 17, etc., up to 77 for gold.

There appears to be little doubt that the X-ray spectrum of an element arises from the vibrations of the rings of electrons deep in the atomic structure outside the nucleus. Quite apart from the very interesting question of the mode of origin of these very high frequency spectra, it is seen that the fundamental modes of vibration of the distribution of electrons are simply connected with the square of a number, which varies by unity in passing from one element to the next. There appears to be no doubt that the atomic number represents the number of units of positive charge carried by the nucleus, which on account of the atomic nature of electricity can only vary by whole numbers and not by fractions.

It is obvious that the study of X-ray spectra reveals at once whether any atomic number is missing, and also affords a remarkably simple method of settling the number of elements possible in the rare earth group about which there has been so much difference of opinion. Moseley concluded that from aluminium to gold, only three possible elements were missing which should have atomic numbers 43, 61, 75, and only one element of number 61 appears to be missing in the rare earth group. The frequencies of the X-ray spectra of these missing elements can be calculated with certainty, and these data should prove an invaluable aid in a search for these missing elements. It has long been known that nickel and cobalt occupy an anomalous position in the periodic table when arranged according to atomic weights. This difficulty is now removed, for Moseley found that when arranged in order of nucleus charge, both elements fall into the position to be expected from their chemical properties.

Nucleus Charge and Chemical Properties

It is established by the work of Moseley that the elements can be defined by their nucleus charge, and that probably elements exist which

have all the nucleus charges from 1 for hydrogen to 92 for lead. There is, however, another very important consequence that follows from this conception of the atom. Disregarding for a moment the atomic weight which depends mainly on the structure of the nucleus, the main physical and chemical properties of the atom are determined by the nucleus charge and not by the atomic mass. This must obviously be the case, for the number and distribution of electrons round the nucleus is determined by the electric forces between the electrons and the nucleus, and this is dependent on the magnitude of the nucleus charge which may be regarded as a point charge. Without entering into the difficult question of the actual distribution of the exterior electrons in any atom, it is obvious that the number and position of the outlying electrons of the atomic structure, which probably mainly influence the chemical and physical properties of the atom, are determined by the charge on the nucleus. No doubt if the electrons are in motion, their positions relative to the nucleus and possibly also their rates of vibration will be slightly influenced by the mass of the nucleus as well as its charge, but the general evidence indicates that this effect must be very small.

We thus see that there is in the structure of every atom a quantity which is more fundamental and important than its atomic weight, viz., its nuclear charge. It is known that the variation of the atomic weights of the elements with atomic number, while showing certain well-marked relationships, shows no definite regularity. From the point of view of the nucleus theory, the atomic weight of an element, while in some cases approximately proportional to its atomic number, is in reality a complicated function of the actual structure of the nucleus. The question why the atomic mass should not necessarily be proportional to the atomic number has already been discussed. While the main properties of an atom are controlled by its nuclear charge, the property of gravitation and also that of radioactivity are to be ascribed mainly, if not entirely, to the nucleus.

Radioactive Elements and the Periodic Series

Since the nucleus charge of an atom determines the main physical and chemical properties of an atom, it is possible that elements may exist of equal nuclear charges but different atomic weights. For example, if it were possible to add a helium nucleus to the nucleus of another atom, it would increase the nuclear charge by two and the mass by about four; if instead of the helium nucleus two hydrogen nuclei were added, the charge would be the same but the mass of the resulting atom two units less than with helium. In such a case, two atoms would be possible of identical nuclear charge but different atomic weights. In a similar way, it may be possible for elements to exist of the same atomic mass but *different* nuclear charges. This would be brought about by the loss or gain of one or more negative electrons in the nucleus.

The study of radioactive elements has in the last year thrown a flood of light not only on this problem but on the underlying meaning of the periodic law of the elements. Russell, Fajans and Soddy independently put forward a remarkable and important generalization in regard to the change of chemical properties of the successive products of transformation of the primary radioactive elements. This generalization can be very simply expressed in terms of the usual arrangement of the elements in groups according to the periodic law. It is found that after a transformation in which alpha particles are expelled, the resulting element has chemical properties which shift its place two groups lower in the direction of diminishing mass. On the other hand, the element resulting from a beta ray transformation shifts one place in the opposite direction. For example, radium, which is in group II., changes after loss of an alpha particle into the emanation into group 0, which included all the inert gases of the helium-argon type. The emanation after loss of another particle becomes radium A, which belongs to group VI., and this in turn becomes radium B belonging to group IV. Since radium B is transformed by the loss of a beta particle, the resulting element radium C takes up a position in group V. By this simple rule, it has been found possible to define the essential chemical properties of all known radioactive elements. It was found that on this theory one element was missing in the general scheme. This element was discovered a few weeks later by Fajans and Göhring, and found to have the general chemical properties predicted for it.

This generalization is capable of a very simple explanation on the nucleus theory. The loss of an alpha particle of charge 2 *lowers* the nuclear charge of the resulting elements two units; the loss of a beta particle, which carries a unit negative charge, *raises* the nuclear charge by one unit. In other words, the atomic number of an element shifts two units lower after loss of an alpha particle and shifts one unit higher after loss of a beta particle.

The atomic numbers of the elements in the uranium-radium series can be simply deduced from this rule if the atomic number of one element is known. We shall see later that the atomic number of radium B is 82 and identical with that of lead. The actual atomic numbers of the various elements are given in the circles representing the atoms in Fig. 12. It is seen that uranium, the heaviest known element, has an atomic number 92, while the elements radium B, radium D and the end product, which is believed to be lead, have the same atomic number, viz., 82. The evidence of the correctness of this striking conclusion will now be discussed.

As a result of a careful examination of the radioactive substances, it has been found that in a number of cases elements, which are of different atomic weight and exhibit different radioactive properties, yet

show identical general physical and chemical behavior. For example, the elements radium B, radium D and lead, of atomic weights 214, 210, and 207, respectively, are so closely allied in chemical and physical properties that all attempts to separate a mixture of any two of them have failed completely. This would be explained if the nuclear charges were identical for those elements, as the generalization, already referred to, indicates. If this be the case, they should give identical spectra under similar conditions. Unfortunately the elements radium B and radium D are in too small quantity to determine their ordinary light spectra, but we can compare the X-ray spectrum of lead with that given by radium B under the excitation of its own beta rays. Experiments of this kind were recently made by Dr. Andrade and the writer, and the two spectra were found to be identical within the limits of experimental error. It is to be anticipated that their light spectra would also prove to be identical, or nearly so, for, as previously pointed out, the effect of the mass of the nucleus on the spectrum is probably very small.

The fact that the atoms of these three elements are not identical as regards mass or radioactive properties, shows that the structure of the nucleus is different in each case.

There is another important deduction that should be mentioned. The end product of the uranium-radium series is an inactive element which has long been considered to be lead, but it has been difficult to verify this conclusion by direct experiment. We have seen that the end product has the same atomic number as lead, but should have an atomic weight about 206 instead of 207 as found for ordinary lead. In a similar way, it has been concluded by Soddy and Fajans that the end product of thorium has the same atomic number as lead, but should have an atomic weight about 208.5. In order to test these remarkable conclusions, experiments are now in progress by a number of investigators in different countries to examine whether the lead always found in radioactive minerals and which presumably has partly, if not wholly, a radioactive origin, shows the same atomic weight as ordinary lead. Soddy has already found evidence that there is a distinct difference in the atomic weights in the direction predicted by the theory.[3]

The question naturally arises whether some of the ordinary elements may not prove to be a mixture of two, or even more, of these "isotopes," as they have been termed. Unless the component isotopes are present in different proportion in different natural sources of the element, it will be difficult to settle this problem by ordinary chemical methods.

[3] Since the delivery of this lecture, similar conclusions have been reached by the experiments of Richards in Cambridge and Hönigschmid in Vienna. There still, however, remains some doubt as to the actual difference in atomic weight of uranium lead, thorium lead and ordinary lead. A very promising beginning has thus been made on the attack of this most important and fundamental problem.

There is one element, however, besides lead, about which interesting evidence has been obtained on this point. Sir J. J. Thomson found by examining the deflection of the positively charged particles produced by an electric discharge through the rare gas, neon, that two elements were present of atomic weights about 20 (neon) and 22. Aston was able by diffusion experiments to separate partially the two components of neon and to show that they differed in density, but failed in attempts to separate them by fractional distillation in charcoal cooled by liquid air. Such results are to be anticipated if neon is a mixture of two isotopes, *i. e.*, elements of identical nuclear charges but different atomic weights.

It is obvious that this new point of view will result in a systematic examination of the elements to test for the possible presence of isotopes, and thus give an additional reason for the accurate determination of atomic weights for elements obtained from widely different sources.

Distribution of Electrons in the Atom

It is seen that the nucleus theory of the atom offers a simple explanation of many important facts which have been brought to light in recent years, and for this purpose it has not been necessary to make any special assumptions as to the actual structure of the nucleus, or of the way in which the external electrons are distributed. The investigation of the latter problem is beset with many difficulties; for an electron is attracted towards the nucleus, and even if it is in orbital motion, it must on the electromagnetic theory lose energy by radiation and ultimately fall into the nucleus. It appears likely that this difficulty is in reality due to our ignorance of the conditions under which an electron radiates energy. According to the views outlined in this lecture, the hydrogen atom has the simplest possible structure, for it consists of a nucleus of one unit charge and one negative electron. The question naturally arises how such a simple structure can give rise to the complex spectrum observed for hydrogen. This problem has been attacked in a series of remarkable papers by Bohr, who concludes that the complexity of the spectrum is not due to the complexity of the atomic structure but to the variety of modes in which an electron can emit radiation. Suppose, for example, that a hydrogen atom has lost its negative electron. Bohr supposes that an electron falling towards the positively charged nucleus may occupy temporarily any one of a number of stationary positions fixed relatively to the nucleus. In falling from one stationary state to another, radiation is emitted of a definite frequency which is connected with the difference of potential energy E of the electron in the two stationary states by $E \cdot h$ where h is Planck's fundamental constant. On this hypothesis, he has been able to account for the series spectra of hydrogen and to deduce directly from the theory the value of Balmer's constant which plays such an important

part in the spectra of all atoms. In a similar way, the helium atom is supposed to consist of a nucleus of two unit charges surrounded by two electrons. On the theory, the spectrum of helium is connected in a very simple way with that of hydrogen. Bohr also pointed out that the Pickering series of spectral lines observed in certain stars which were originally attributed to hydrogen must be ascribed to helium. This conclusion has since been strongly supported by the direct experiments of Fowler and Evans. In a similar way, Bohr described the possible distribution of electrons in several of the lighter atoms and also discussed the structure of the hydrogen molecule, which is composed of two hydrogen nuclei and two electrons. The heat of combination deduced for the theoretical molecule is in fair accord with experiment. He found that two helium atoms were unable to unite to form a molecule—in agreement with a well-known property of this gas.

While there is room for much difference of opinion as to the interpretation of the rather revolutionary assumptions made by Bohr to explain the structure of the simple atoms and molecules, there can be no doubt of the great interest and importance of this first attempt to deduce the structure of the simple atoms and to explain the origin of their spectra. The agreement of the properties of such theoretical structures with the actual atoms is in several cases so remarkable that it is difficult to believe that the theory is not in some way an expression of the actual facts. While much work will be necessary before we can hope to understand the structure of any but the simplest atoms, a promising beginning has been made in the attack on this most difficult and fundamental of problems.

There seems to be little doubt that the more marked physical and chemical properties of an atom are to be attributed to a few outlying electrons in the atomic structure. The position and number of these "valency" electrons, as they have been termed by Stark, are defined by the magnitude of the nucleus charge. It has previously been pointed out that the loss of an alpha particle from a radioactive atom changes the position of the element two groups lower in the periodic table, while the loss of a beta particle raises it one group higher. Consequently it follows that the loss or gain of a unit charge from the nucleus of an atom causes it to change its position from one group to the next. If, for example, we follow the chemical properties of successive elements when the nucleus charge increases by unity, we soon reach an element which belongs to the same group as the first, although of much higher atomic weight. We must consequently conclude that the number and position of the outlying electrons in the structure of the atom passes through successive changes which are regularly repeated with increasing atomic weight. Quite apart from any detailed knowledge of the electronic distribution of atoms, the regular recurrence of elements of

similar chemical properties with increasing atomic weight is to be anticipated on the general theory that an atom is an electrical structure.

Evolution of the Elements

It has long been thought probable that the elements are all built up of some fundamental substance, and Prout's well-known hypothesis that all atoms are composed of hydrogen is one of the best known examples of this idea. The evidence of radioactivity certainly indicates that the heavy radioactive elements are in part composed of helium, for an atom of the latter appears as a result of many of the radioactive transformations. No definite evidence, however, has been obtained that hydrogen appears as a result of such transformations; but as previously pointed out, helium may prove to be an important secondary unit in the structure of heavy atoms. While we have thus undoubted evidence of the breaking up of heavy atoms, no indication has yet been observed that the radioactive processes are reversible under ordinary conditions. Many investigations have been made to test whether new elements appear in strong electric discharges in vacuum tubes. While some of the results obtained are difficult of interpretation, no reliable evidence has yet been adduced that one element can be transformed into another under such conditions.

The question of the evolution of the elements has been attacked from another side. Sir Norman Lockyer and others have suggested that the elements composing the star are in a state of inorganic evolution. In the hottest stars the spectra of hydrogen and helium predominate, but with decreasing temperature, the spectra becomes more complicated and the lines of heavier elements appear. On this view, it is supposed that the light elements combine with decreasing temperature to form the heavier elements.

There is no doubt that it will prove a very difficult task to bring about the transmutation of matter under ordinary terrestrial conditions. The enormous evolution of energy which accompanies the transformation of radioactive matter affords some indication of the great intensity of the forces that will be required to build up lighter into heavier atoms. On the point of view outlined in these lectures, the building up of a new atom will require the addition to the atomic nucleus of either the nucleus of hydrogen or of helium, or a combination of these nuclei. On present data, this is only possible if the hydrogen or helium atom is shot into the atom with such great speed that it passes close to the nucleus. In any case, it presumes there are forces close to the nucleus which are equivalent to forces of attraction for positively charged masses. It is possible that the nucleus of an atom may be altered either by direct collision of the nucleus with very swift electrons or atoms of helium such as are ejected from radioactive matter. There is

no doubt that under favorable conditions, these particles must pass very close to the nucleus and may either lead to a disruption of the nucleus or to a combination with it. Unfortunately, the chance of such a disruption or combination is so small under experimental conditions that the amount of new matter which is possible of formation within a reasonable time would be exceedingly small, and so very difficult of detection by direct methods. Very penetrating X rays or gamma rays may for similar reasons prove to be possible agencies for changing atoms. Although it is difficult to obtain direct evidence, I personally am inclined to believe that all atoms are built up of positive electrons—hydrogen nuclei—and negative electrons, and that atoms are purely electrical structures.

There can be little doubt that conditions have existed in the past in which these electrons have combined to form the atoms of the elements, and it may be quite possible under the very intense electrical disturbances which may exist in hot stars that the process of combination and dissociation of atoms still continues.

In these lectures, I have tried to give an idea of some modern views of the structure of the atoms and of the great variety of new and powerful methods which have been applied to the attack of this problem in recent years. We have seen that a heavy atom is undoubtedly a complex electrical system consisting of positively and negatively charged particles in rapid motion. The general evidence indicates that each atom contains at its center a massive charged nucleus or core of very small dimensions surrounded by a cluster of electrons probably in rapid motion which extend for distances from the center very great compared with the diameter of the nucleus. Such a view affords a reasonable and simple explanation of many important facts obtained in recent years, but so far only a beginning has been made in the attack on the detailed structure of atoms—that fundamental problem which lies at the basis of physics and chemistry.

WAR SELECTION IN WESTERN EUROPE

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France

EUROPE had no finer human stock than that of France, and no modern people has suffered more from the ravages of war and glory. The Gauls, as they appear in early history, were a Celtic race. Conquest made them Gallo-Roman. Later, especially in the north and east, their blood was strengthened by Teutonic strains—the Normans from Scandinavia and the Franks from Central Germany. In later days a large influx from Germanic Alsace has made German names common in French society.

Through reversal of selection by war, the men of France lost in stature, and the nation in initiative. But a good stock possesses power of recuperation, and regenerative processes have been evident in France for the last twenty years. Peace and security, industry and economy enable the natural forces of selection to operate. This means race regeneration. The nation had been sorely wounded by her own sons. She has been making a healthy recovery.[1]

In the Wiertz gallery in Brussels is a striking painting, dating from the time of Napoleon, called "A Scene in Hell" ("Une Scène dans l'Enfer"). It represents the great marshal with folded arms and face unmoved descending slowly to the land of the shades. Before him filling all the background of the picture, their faces expressing every form of reproach, are the men sent to death before their time by his

[1] "Land, money, tradition and prestige," says Professor Albert Léon Guerard ("French Civilization in the Nineteenth Century," 1912), "would be naught if the people had lost its soul. Their wealth would pass into stronger hands, and their prestige to contempt. Once, about twenty years ago, the French themselves wondered if it had not come to that. The cry of a decadence was raised by malevolent rivals, by sensationalists, by esthetics in quest of a new pose, by earnest patriots who had lost their star. When a belated echo of this reaches us now, how faint and strange and silly it sounds. For the one great asset of the French is their indomitable vitality. Even in wasteful conflict one can not fail to admire the evidence of power. In the twentieth century as ever before the French are among the pioneers.

"I do not see France as a goddess, austere and remote. I see her intensely human, stained with indecencies and blasphemies, scarred with innumerable battles, often blinded and stumbling on the way, but fighting on undismayed, for ideals which she can not always define. An old nation? A wounded nation? Perhaps, but her mighty heart is throbbing with unconquerable life."

unbridled ambition. Four millions there were in all, more than half of them Frenchmen. And behind the legions shown or hinted at, one seems to discern the millions on millions who might have been and are not—the huge widening wedge of the possible descendants of those who fell in battle, youth without blemish ("l'élite de l'Europe"), made "flesh for the cannon" in the rush of Napoleon's great campaigns.

These came from the farm, the workshop, the school, "the best that the nation could bring," men from eighteen to thirty-five years of age at first, but afterwards the older and the younger. Napoleon said:

> A boy will stop a bullet as well as a man.

Says Professor Haeckel:

> The more vigorous and well-born a young man is the more normally constituted, the greater his chance to be slain by musket or magazine, the rifled cannon and other similar engines of civilization.

Says Seeck:

> Napoleon, in a series of years seized all the youth of high stature and left them scattered over many battlefields, so that the French people who followed them are mostly of smaller stature. More than once since Napoleon's time has the military limit been lowered.

In the career of Napoleon campaign followed campaign, against enemies, against neutrals, against friends. Conscription followed victory, both victory and conscription debasing the human species. Again conscription after conscription.

> Let them die with arms in their hands. Their death is glorious, and it will be avenged. You can always fill the places of soldiers. . . . A great soldier like me doesn't care a tinker's dam for the lives of a million men.

Still more conscription. After Wagram, France began to feel its weakness, the "Grand Army" being no longer the army which had fought at Ulm and Jena.

> Raw conscripts raised before their time and hurriedly drafted into the line had impaired its steadiness.

After Moscow, homeward

> amidst ever-deepening misery they struggled on, until of the six hundred thousand men who had proudly crossed the Nieman for the conquest of Russia, only twenty thousand famished, frostbitten, unarmed specters staggered across the bridge of Korno in the middle of December. . . . Despite the loss of the most splendid army marshalled by man, Napoleon abated no whit of his resolve to dominate Germany and discipline Russia. . . . He strained every effort to call the youth of the empire to arms . . . and 350,000 conscripts were promised by the senate. The mighty swirl of the Moscow campaign sucked in 150,000 lads of under twenty years of age into the devouring vortex. . . . The peasantry gave up their sons as food for cannon.

But

> many were appalled at the frightful drain on the nation's strength. . . . In less than half a year after the loss of half a million men a new army nearly as numerous was marshalled under the imperial eagles. But the majority were

young, untrained troops, and it was remarked that the conscripts born in the year of terror had not the stamina of the earlier levies. Brave they were, superbly brave, and the emperor sought by every means to breathe into them his indomitable spirit. (J. H. Rose.) Truly the emperor could make boys heroes, but he could never repair the losses of 1812. . . . Soldiers were wanting, youths were dragged forth. . . . To fill hell with heroes,

—in these words some one has summed up the life-work of Napoleon. "J'ai cent mille hommes de rente," "My income is a hundred thousand men," said Napoleon. But to a terrible degree he lived beyond his income.

French writers have been very frank in the discussion of national deficiencies and mistakes. They have wished to conceal nothing from France and therefore nothing from the world. Their admissions have been exaggerated by unfriendly critics. It has been claimed that modern France, with the other Latin nations, is a "decadent state," that she has passed her prime and is now in the weakness and sterility of old age, her place as the dominating force on the continent of Europe having been yielded to a younger and more aggressive power. If its strong strains are not wholly extirpated, peace and security will renew its youth. Decrepitude in a nation is due not to age, but to the operations of war, as we have several times insisted, followed by the loss of its best strains of blood and their replacement by recruiting from immigrants of the weaker races. Though France has suffered grievously from war, as a nation she has lost little from immigration and not much from emigration.

Certain features of French life have been indicated as evidences of injury from reversal of selection. The birthrate of France, already low, has been steadily falling. This is apparently a result of the survival of the cautious, for Napoleon's dashing grenadiers could hardly be imagined to limit their families for prudential reasons of economy. Indeed, the French in Canada, not affected by war, are notoriously fecund. Another evidence of the survival of the cautious is found in the relative lack of business enterprise in France. The gold hoarded in her stockings has been used mainly for international loans, rarely for business development, foreign loans yielding a higher interest with less personal responsibility. And the absence of factory towns emphasizes the fall in the birthrate, as in civilized nations a high rate of increase occurs mainly in industrial centers.

Edmond Demolins in a clever book asks: "In what constitutes the superiority of the Anglo-Saxon?" He finds his answer in the false standards in French life, in defects of training and of civic and personal ideals. The desire for seats in a government bureau and for similar safe places of routine and without initiative has been termed in Italy "Impiegomania," the "craze for sitting down." The eagerness to secure such positions is said to be a besetting sin of the youth of both Italy and France. But the fault may be due to over-centraliza-

tion of government, too many officials and too little opportunity in the provincial centers, rather than to any fault in the nature of the individual man. Nationalization of effort, whether through socialism or through "efficient organization," must contribute to the spread of "impiegomania."

If the strictures of Demolins be true in any degree, this may be the interpretation. Inferior standards are the work of inferior men. Great men there are in France, and these have persistently turned the nation's face toward the light since Demolins's book was written. War's effect has been to rob France of her due proportion of leaders, but not to dilute or to weaken the message of those who survive. The evolution of a race is always selective, never collective. Collective evolution among men or beasts, the movement upward or downward of the whole as a whole, irrespective of training or selection, is never a fact. As La Pouge has said:

> It exists in rhetoric, not in truth nor in history.

Another line of criticism of France finds its ablest exponent in Dr. Max Nordau, whose book on "Degeneration" aroused the attention of the world some twenty years ago. Nordau finds abundant evidences of degeneration in the art and literature of every land, all forms of eccentricity, pessimism and perversity being regarded as such. In France, such evidences he finds peculiarly conspicuous. The cause of this condition he ascribes to the inherited strain of an overwrought civilization. "Fin de siècle," "end of the century" is the catchphrase expressing the weariness, mental, physical and spiritual of a race "tired before it was born." To Nordau, this theory adequately explains all eccentricities of French literature, art, politics or jurisprudence.

But in fact we have no knowledge of the existence of nerve-stress inheritance. In any event, the peasantry of France have not been subjected to it. Their life is hard, but not stressful; and they suffer more from monotony than from any form of enforced nerve-activity. The kind of degeneration Nordau pictures is not a matter of heredity. When not simply personal eccentricity, it is a phase of personal decay. It finds its causes in bad habits, bad training, bad morals, or in the desire to catch public attention for personal advantage. It has no permanence in the blood of the race. The presence on the Paris boulevards of eccentric painters, maudlin musicians, absinthine poets and sensation-mongers, proves nothing as to race degeneracy. When the fashion changes, they will change also. The "end of the century" is past and already the fad of "strenuous life" is blowing them away. Any man of any race withers in an atmosphere of vice, absinthe and opium. The presence of such an atmosphere may be a disheartening symptom, but it is not a proof of national decline. The ghastliest and

the most depraved of Parisian sensations are invented to meet the jaded fancy of gilded youth from across the sea.

A French cartoon more than a century old pictures a peasant ploughing in the field, hopeless and dejected, a frilled and cynical marquis on his back, tapping his gilded snuff-box. A recent one shows the peasant still at the plough and equally hopeless. The marquis is gone, but in his place sits a soldier armed to the teeth, who ought himself to be at the plough, while on the soldier's back rides the money-lender, colder and more crushing than the dainty marquis, for the money-lender is the visible exponent of the war-trader, most sinister and most burdensome of all purveyors of implements of destruction.

For more than forty years past France has lived under the shadow of war. The loss of Alsace-Lorraine cut a deep wound in French emotions as well as in French pride. The noble attitude of the lost provinces stimulated the natural determination for the "war of honor," the "war of revenge." But as time went on, it became more and more evident that such a war could never be successful. And after the collapse of the inflated militarism of Boulenger, and in view of the sordid failure of military honor as shown in the "Dreyfus case," the people of France began generally to doubt the righteousness as well as the wisdom of war against Germany. In 1913, the influential men of France were willing to meet half way the "Friedensfreunde" of Germany. The writer was present at Nürnberg in 1913, at a great mass meeting in which the Baron D'Estournelles de Constant spoke warmly and eloquently for international friendship. France was becoming ready to forgive if not to forget. But this the Prussian military system in Alsace-Lorraine would not permit. They had left the united province of Elsass-Lothringen without citizens' rights as *"Reichsland"* or Imperial territory, it being an *"Eroberung"* or conquest. They had subjected it to the process of *"Entwelschung"* or deforeignization, by means of trivial and burdensome *"Abwehrgesetze,"* or special statutes directed mainly against the use of the French language. The people of Alsace-Lorraine, those of Germanic and French stock alike, could not forget. And for this reason France could not. Had the united provinces been given full autonomy within the German Empire and their people been made full citizens instead of "Deutsche Zweiter Classe," "the nightmare of Europe,"[2] the question of Alsace-Lorraine would long ago have vanished from European politics.

It is a common saying in France, that the Frenchmen of to-day are small because our tall ancestors were killed in our victorious wars.

The statistics behind this statement have been made the basis of a critical study by Professor Vernon L. Kellogg. A synopsis of the results of this study is given in *Social Hygiene,* December, 1914.[3]

[2] "La cauchemar de l'Europe."

[3] It should be clearly noted that a mere decline in stature is in itself of

little racial significance, save as an index in decline in other and more vital regards. Tall stature has been sought for in recruiting armies and so have qualities of boldness and dash. The decline in stature can be measured; the other qualities can not, but we may fairly assume that all soldierly traits have suffered together and the measure of the one serves in some degree as the measure of all.

France has kept for over a century an interesting set of official records which offers most valuable data for the scrutiny of the biologic student of war. They are the records of the physical examination of all the male youths of France as these youths reach their twentieth year of age, and offer themselves, compulsorily, for conscription. To determine who realize the condition of minimum height, weight, chest measurement, and the freedom from infirmity and disease necessary for actual service, all are examined and the results recorded. These records show, therefore, for each year very clearly and precisely the physical status of the new generation of Frenchmen.

The minimum physical condition for actual enlistment has varied much with the varying needs of the nation for men of war. In certain warring periods of her history France has had to drain to the very limit her resources in men able to bear arms. Most notably this condition obtained during the nearly continuous twenty-year period of the Napoleonic Wars.

Louis XIV. in 1701 fixed the minimum height of soldiers at 1,624 mm. But Napoleon reduced it in 1799 to 1,598 mm. (an inch lower) and in 1804 he lowered it two inches further, namely to 1,544 mm. It remained at this figure until the Restoration, when (1818) it was raised by an inch and a quarter, that is, to 1,570 mm. In 1830, at the time of the war with Spain, it was lowered again to 1,540 mm., and finally, in 1832 again raised to 1,560 mm. Napoleon had also to reduce the figure of minimum age.

The death list, both in actual numbers and in percentage of all men called to the colors, during the long and terrible wars of the Revolution and Empire, was enormous. And the actual results in racial modification due to the removal from the breeding population of France of its able-bodied male youth, leaving its feeble-bodied youth and senescent maturity at home to be the fathers of the new generation, is plainly visible in the condition of the conscripts of later years.

From the recruiting statistics, as officially recorded, it may be stated with confidence that the average height of the men of France began notably to decrease with the coming of age in 1813 and on, of the young men born in the years of the Revolutionary Wars (1792–1802), and that it continued to decrease in the following years with the coming of age of youths born during the Wars of the Empire. Soon after the cessation of these terrible man-draining wars, for the maintenance of which a great part of the able-bodied male population of France had been withdrawn from their families and the duties of reproduction, and much of this part actually sacrificed, a new type of boys began to be born, boys that had in them an inheritance of stature that carried them by the time of their coming of age in the late 1830's and 40's to a height an inch greater than that of the earlier generations born in war time. The average height of the annual conscription contingent born during the Napoleonic Wars was about 1,625 mm.; of those born after the war it was about 1,655 mm.

The fluctuation of the height of the young men of France had as obvious result a steady increase and later decrease in the number of conscripts exempted in successive wars from military service because of undersize. Immediately after the Restoration, when the minimum height standard was raised from 1,544 mm. to 1,570 mm., certain French departments were quite unable

to complete the number of men which they ought to furnish as young soldiers of sufficient height and vigor according to proportion of their population.

Running nearly parallel with the fluctuation in number of exemptions for undersize is the fluctuation in number of exemptions for infirmities. These exemptions increased by one third in twenty years. Exemptions for undersize and infirmities together nearly doubled in number. But the lessening again of the figure of exemptions for infirmities was not so easily accomplished as was that of the figure for undersize. The influence of the Napoleonic Wars was felt by the nation, and revealed by its recruiting statistics, for a far longer time in its aspect of producing a racial deterioration as to vigor than in its aspect of producing a lessening stature.

It is sometimes claimed that military selection is of biological advantage to the race as a purifier by fire. This might indeed be true if it were the whole population that was exposed. But it is only a certain part of it that is so exposed, a part chosen on a basis of conditions very pertinent to racial integrity. For in the first place it is composed exclusively of men, its removal thus tending to disturb the sex-equilibrium of the population, and to prevent normal and advantageous sexual selection. Next, these men are all of them of greatest sexual vigor and fecundity. Finally they are all men, none of whom fall below and most of whom exceed a certain desirable standard of physical vigor and freedom from infirmity and disease.

War's selection is exercised on an already selected part of the population. And every death in war means the death of a man physically superior to at least some other man retained in the civil population. For the actual figures of present-day recruitment in the great European states show that of the men gathered by conscription, as in France and Germany, or by voluntary enlistment, as in Great Britain, from 40 to 50 per centum are rejected by the examining boards as unfit for service because of undersize, infirmities, or disease.

Nor is it necessary that these selected men be actually removed by death in order that militarism may effect its deplorable racial hurt. For this removal even for a comparatively short time of a considerable body of these men from the reproductive duties of the population, and their special exposure to injury and disease—disease, we shall see, of a particularly dangerous character to the race—is in itself a factor sufficient to make military selection a real and dangerous thing.

Death in war comes not always nor even most often in battle. It comes more often from disease. And disease, until very recent years, and even now except in the armies of certain few countries, has stricken and still strikes soldiers not only in war time but in the pipingest time of peace. And, what is almost worse for the individual and decidedly so for the race, its stroke is less often death than permanent infirmity. The constant invaliding home of the broken-down men to join the civil population is one of the most serious dysgenic features of militarism.

In the French army in France, Algeria, and Tunis in the thirteen-year period 1872–1884, with a mean annual strength of 413,493 men, the mean annual cases of typhoid were 11,640, or one typhoid case to every 36 soldiers! In the middle of the last century the mortality among the armies on peace footing in France, Prussia, and England was almost exactly 50 per cent. greater than among the civil population. When parts of the armies were serving abroad, especially if in the tropics, the mortality was greatly increased. In 1877 the deaths from phthisis in the British army were two to one in the civil population. And how suggestive this is, when we recall that the examining boards reject all obviously phthisis-tainted men from the recruits. The proportion was still three to two as late as 1884. In the last war of our own

German officials have claimed that military service "provides a special advantage to developing manhood in its compulsory exercise, enforced habits of discipline, unescapable stimulus to patriotism and general moral control." In the words of a German general, quoted by Professor Kellogg,

> military service is not injurious to the body, but healthful, not depressing to mind and spirit, but inspiring.

Some of these alleged virtues will not appear as such under other and perhaps more truthful names. But admitting all that may be said, the armies exist for war; their members "especially selected and zealously cared for" are chosen for sacrifice, and the more worthy the sacrifice the greater the permanent loss to the nation. When a man of character and ability, says Professor Kellogg,

> gives his life, in war, to his nation, he gives more than himself. He gives the long line, the ever widening wedge of those who should be his descendants. In the long run these may have greater potential value than any political end they have helped to accomplish.
>
> The most economical and most positive factor in human progress is good breeding. Race deterioration comes chiefly from its opposite, bad breeding. Militarism encourages bad breeding.
>
> Despite all delusive phrases to the contrary, the maintenance of an army is a preparation for war and a step toward war and not toward peace. Do governments, or will they, maintain this blessing of military service for the health and eugenic advantage of their people? Is it not done solely from the stimulus of expected war? Is it not done solely with the full expectancy and deliberate intention of offering this particularly selected and cared for part of the population to the exposure of wholesale mutilation and death? This death is to come, if at all, before this extra-rigorous part of the population has taken its part in race propagation, the precise function the performance of which the race most needs from it.

Spain

The Spain of to-day is not the Spain of 1493 to whom the Pope assigned half the seas of the world. Old Spain drooped long ago, exhausted with intolerance, sea power and empire. Now that modern Spain has been deprived of the last vestige of imperial control, she is slowly recuperating on a foundation of industry and economy.

In 1630, the Augustinian friar, La Puente, thus wrote of the fate of Spain:

> scientifically enlightened country, the deaths from disease in camp were eight to one from the incidents of battle. But we could do better now. And so could France and England.
>
> In fact, the modern humane war against disease has made life much safer for the soldier. That is to be admitted. But there has occurred so far but one conspicuous radical exception to the general rule of a much greater percentage of deaths from disease than from bullets and bayonets in war time. That, of course, is the record of the Japanese armies in the Russo-Japanese war. The records of the recent war in the Balkan States are like those of a century ago.

Against the credit for redeemed souls I set the cost of armadas and the sacrifice of soldiers and friars sent to the Philippines. And this I count the chief loss; for mines give silver, and forests give timber, but only Spain gives Spaniards, and she may give so many that she may be left desolate, and constrained to bring up strangers' children instead of her own.

Said a Spanish knight:

This is Castile, she makes men and wastes them.

Says Captain Carlos Gilman Calkins:

This sublime and terrible phrase sums up Spanish history.

Says Havelock Ellis:

Everything has happened that could happen to kill out the virile, militant, independent elements of Spanish manhood.[4] War alone, if sufficiently prolonged and severe, suffices to deplete the nation of its most vigorous stocks. "The warlike nation of to-day . . . is the decadent nation of to-morrow." The martial ardor and success of the Spaniards lasted for more than a thousand years. It was only at very great cost that the Romans subdued the Iberians and down to the sixteenth century, the Spaniards were great soldiers. The struggle in the Netherlands wasted their energies and then finally at Rocroy, in the middle of the seventeenth century, the Spanish infantry that had been counted the finest in Europe went down before the French, the military splendor of Spain vanished" ("The Soul of Spain").

It is a question whether Spain suffered most from the scattering of her strong men over seas, from her perpetual struggles in Europe or from the Inquisition. This sinister institution was more wasteful and more cruel in Spain than anywhere else, leading to the extinction of independent minds and of virile intellectuality.

In Spain as in France, the continuance of peace with the cessation of the loss and waste over seas is bringing a financial and industrial recuperation, which must be slowly followed by a physical and moral advance. It is claimed that Spain now enjoys "an intellectual and artistic renaissance that will make her memorable when her heroes are forgotten."

Germany

Germany suffered perhaps scarcely less than France from the wars of Louis XIV. and of the two Napoleons. German writers, however, have been much less frank than the French and also less lucid in discussing their national disabilities. They have given but scanty records of the racial waste their wars have involved. Moreover, the organization of modern Germany, a socialist state under military domination, has tended to minimize the visible distinctions among racial strains. Every man has his place. It is not easy to fall below one's class, correspondingly difficult to rise. Universal compulsory education, technical as well as academic, saves even the feeble from absolute incom-

[4] In this connection, Mr. Ellis extolls the beauty, grace and spirit of the Spanish women and suggests the theory that so far as feminine traits go, there has been no reversal of selection. "The women of Spain," he thinks, "are on the average superior to the men."

petence. The three duties of the citizen, "Soldat sein; Steuer; Mund halten" (be a soldier; pay taxes; hold your tongue), are simple and do not encourage initiative. Universal conscription binds the individual into subjection to the central power. He has the choice between docile acceptance of a fate not wholly intolerable, and revolt with probable misery or death. Forms of insurance against poverty, unemployment or old age guard him against total failure. The difficulties which beset the common man in trying to enter the "learned proletariat" of the universities or the sublimated caste of the army deter all but the most gifted from ambition for advancement. Only real genius for scholarship or for money-getting can break the bonds of caste. This system minimizes the miseries of poverty, while at the same time it checks initiative in the mass of the people.

In general, it subordinates individual freedom to a prearranged discipline of efficiency. This has culminated in the development of the army and navy. To those who regard the dominance of militarism as a survival of savagery, the recrudescence of military ideals in Germany seems one of the saddest results of modern scientific advance.[5]

The victory over France in 1871 has had the effect of intensifying the military spirit of Germany, and of making its extension appear an integral part of the nation's commercial and industrial growth. This fact operates toward final disaster, for whether successful or not in the struggle with the allied powers, the aggregate result will be of the nature of terrible defeat. When the record is summed up it may appear that Germany rather than France is the final sufferer from the Franco-Prussian war and the "blood and iron" policy of Bismarck and his successors.

England

In England, before the Great War, one often heard complaints of the decadence of the nation. This is a habit of the British press in the summer months in the intervals between sensations. The yeomanry were disappearing. The slums of London, Manchester, Liverpool were centers of sweat-shops and child labor, of wasting overwork, of infant mortality, and malnutrition, of sodden drunkenness and helpless old age. And in the higher classes, we were told of "flannelled oafs" and heedless sportsmen, men to whom a cricket match was of more worth than the conservation of empire. Much of this complaint was complacent self-criticism, a favorite amusement with the wealthy unemployed of England. Some of it had the political purpose of discrediting the government, but behind it all rests a certain neglected residuum of truth.

Great Britain has accomplished much in the last century, and much

[5] "To glorify the state is to glorify war, for there is no collective operation which can be so effectively achieved as war, and none which more conspicuously illustrates the sacrifice of the individual to the nation" (Havelock Ellis).

of this has permanent value to the world. She has permeated its thoughts, modified its action and strengthened its character as no other race or nation ever could.

In the Norse mythology, it was the Mitgard serpent which reached around the world, swallowed its own tail and held the world together. England has been the Mitgard-Serpent of history She has made this a British planet. Her young men have gone into all regions where freemen can live. They have built up free institutions held together by the British cement of cooperation and compromise. She has carried her Pax Britannica, the British peace, with its semblance of order and decency, to all barbarous lands, and she has mixed with it enough of freedom to give her rule permanence. She has made it possible for Englishmen to trade and to prey with savages. "What does he know of England, who only England knows?" For the activities of the Greater Britain, of which we of the republic of America form an integral part, are greater by far than those confined to the little island from which the British people set forth to inherit the earth.

What has it all cost? For such great race exertion must take some toll in race exhaustion. This loss will not appear in the decline in ability of statesmen or scholars. It means a decline in their numbers, and the relative increase in numbers of those types of men whom empire can not use.

Much of the force of England has gone out to America and to those self-governing commonwealths no longer to be called colonies, which have spread British traditions over forceful young democracies, who have escaped Britain's greatest evil, the legalization of privilege. But a man is a man, wherever he may live, and we can hardly count the occupation of Canada, Australia, New Zealand and South Africa as loss to the motherland.

But with India the case is not so clear. Men have asked, What has Britain done for India? We may admit that she has done much, and her work, improving with experience, grows more helpful and humane as time goes on. What has India done for Britain? This is a parallel problem little considered, and there is much harm mixed with the good which enters into the calculation. For India has enriched England—a small part of England engaged in overseas trade. The men whom India has made wealthy, men like the Sassoons of the opium trade are not, as a rule, those who share their fortunes with the people, taxed to make these fortunes possible. India has furnished employment for thousands of young Englishmen ("outdoor relief for sons of good families") and it has furnished graves for thousands of British yeomen and British gentlemen, men of spirit whom Britain could ill afford to spare.

A British officer once said to me,

I have seen men who might have been makers of empire die like flies in India.

The methods by which Great Britain, in haphazard fashion, built up her imperial domain have not always been those which conscientious British can defend. They have brought Great Britain into disrepute and they have been used as precedents by rival nations who make no pretense to British scruples. The Great War in Europe has been called the "nemesis of Lord Beaconsfield." Were it not for the imperial chicanery of Lord Beaconsfield's period of unscrupulous glory, the Balkans might never have been fanned into the flames which set all Europe on fire.

England is very rich, if you look at her from above, but her wealth through tradition and through legalization of privilege and abuse is in very few hands. The landholding dukes and the lords of commerce and finance hold the resources of England in their grasp. One fourth the population of Great Britain hold virtually nothing at all. One tenth of them are persistently submerged, and with the waste and havoc of the present war, another tenth will be found to have fallen with them. Says Franklin:

> The profits of no trade can ever be equal to the expense of compelling it by force of armies.

But the profits of the trade obtained through compulsion go to the undeserving few. The cost of compulsion in blood and in gold falls on the body of the nation.

The governments of the world take the risks of imperialism. The great trading, mining, and exploiting corporations receive the gains. In almost every large transaction of any government, there is this constant source of confusion. What the nation expends should be balanced by what the nation receives. It is not enough to estimate "our outgoes" on the one hand and "our receipts" on the other when the outgoes are drains on the public funds, and the receipts are private gains. This fallacy of administration may be found on every hand in connection with almost every item of public expenditure. Public expenditure turned to private gain is the very essence of privilege, and privilege wherever found is the betrayer of justice, the antithesis of democracy. Where privilege exists it violates the principle of equality before the law. In Imperial exploitation a thousand little streams lead from home activities to swell the wealth drawn from overseas.

We admit, says Professor J. Arthur Thomson,

> that wars have been necessary and righteous—especially necessary, and that they may be so still, but this opinion does not affect the fact that prolonged war in which a nation takes part is bound to impoverish the breed, since the character of the breed always depends on the men who are left. The only thing a nation dies of is lack of men and is there not disquieting evidence of the increase of incapables? It is said (in Great Britain) that we can not relax one spine of our national belligerence since we must, at all cost, uphold our national supremacy, having all these teeming millions to feed. But is not this, in part at least, a vicious circle. Is it not preoccupation with militarism that is responsible for keeping up our national misery? With a little money saved off belligerence, what might not be done towards social improvement?

THE PSYCHOLOGY OF WAR

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FROM the flood of writings called out by the war in Europe, a few things have become fairly clear. For instance, it is evident that this is the most costly and the most tragic of all the wars of history, that it has proceeded from the least apparent causes, and that it has come in the face of new and powerful forces making for peace.

But these facts, if such they be, reveal a situation which to the sociologist is more than puzzling, it is amazing. If, as Norman Angell has shown, modern wars are wholly futile so far as the possibility of bringing any kind of gain to the victorious nation is concerned; if war is contrary to the spirit of the age, which is no longer martial, but industrial, commercial and humanitarian; if the contrast between the brutality of war and the culture and refinement of the age is so great that war has become grotesque and anomalous; if the present war is the outgrowth of political rivalries which have largely lost their significance owing to the fact that nearly all present vital human interests have widened out beyond the mere political boundaries of the state and become international in their scope; and if, finally, the nations in order to carry on the war are assuming a debt so crushing that posterity can not exist unless the debt is repudiated in whole or in part, why, then, it would appear that the whole European world has gone insane.

But the student of history and of psychology will look at the matter in quite a different way. He will see that the history of mankind for thousands of years has been a history of incessant warfare and that the new economic and industrial conditions which have made war irrational are not more than about one hundred years old, while the human brain is practically the same old brain of our fathers and forefathers, deeply stamped with ancestral traits and primitive instincts, which can not thus suddenly be outgrown. It is society which has suddenly changed, not the units of society.

Ever since the war began, sociologists, economists, philosophers and political theorists have tried their hands at explaining the causes of the war and with small success. Its roots must be sought in psychology and anthropology.

The anthropologist and historian will review the situation somewhat as follows: The rivalries between nations with their mutual suspicion, distrust and hatred leading to the clash of arms is the survival

of early conflicts between primitive social groups. These conflicts were incessant in all parts of the world wherever there were virile and progressive races and the cause of the conflicts was the natural desire of the stronger to exploit the weaker, it being always easier and more attractive to gain sustenance by robbery than by labor. Furthermore these incessant conflicts were in a high degree beneficial to social development, resulting in the extermination of the unfit and the survival of the strong and the brave. *Within* the primitive groups there was some degree of cooperation, sympathy, mutual helpfulness, regard for life and property, together with some observance of "law" and "order" and "right" and "wrong," this primitive organization resulting perhaps from the rules and regulations imposed by a victorious group upon a conquered group. *Between* the groups there was fear, suspicion, hatred, with no respect for life or property. Might was right. Within the group certain actions were stigmatized as wrong and were punished, such for instance as murder and theft. But between members of hostile groups these acts were praiseworthy.

The modern constitutional state is the historical development of the primitive group. Within the groups, now called nations, the upper classes, nobles, lords, officers, plutocrats, still to a greater or less extent exploit the lower classes, as the victors did the vanquished, and between the groups there is still the old rivalry, suspicion and distrust, while the taking of life and property is still praiseworthy and is not called murder and theft, but war.

But meanwhile within the political state there have grown up two new communities—one moral and the other industrial and commercial, and gradually, while the old bounds of the political state have persisted, the moral and industrial states have expanded till they have burst the bounds of the political state and become international and world wide. A cosmopolitan conscience has replaced the old group conscience and moral obligations extend to all mankind. In time of war between the nations, however, under the transport of patriotism, the old group consciousness revives, with its deep-seated instinct of pugnacity, and with it is revived the old group conscience and the ancient hatred and suspicion, and the ancient desire to exterminate the rival group. Hence the reversion in time of war to primitive standards of conduct.

But under the completely transformed conditions of society in modern times, the original *raison d'être* of war has ceased to be. Victory is no longer to the physically stronger and mentally braver. The vanquished are no longer exterminated or enslaved. The victors lose perhaps as many of their fighters as the vanquished and the disabled are vastly more in number than the dead and both the dead and the disabled are the flower of the nation's youth. Meanwhile, the monstrous cost of a modern war, which impoverishes the nation and its posterity,

the paralysis of a great and intricate system of world commerce and industrial international relations, the colossal destruction of wealth, the irreparable damage to progress and civilization, the impoverished physical heredity of a whole people, the affront to moral ideals slowly and painfully achieved, the untold burden of pain and woe and human suffering in desolated homes far from the field of battle, all combine to make war repulsive and repugnant to modern sense. It no longer cultivates manly virtues but for the most part only machination and mechanical ingenuity.

It is probable that all the benefits which a warring nation hopes to gain by victory are in modern times illusory, or at least they are so far illusory that they are almost if not wholly confined to the circumstances of some hypothetical future war. For instance, a great nation demands the control of some celebrated strait or narrows, so that it may have an outlet for its vast exports—an open way to the sea, although *in time of peace* that nation already has the enjoyment of the freest use of that strait. In other words, were it not for some hypothetical future war, that nation has already the open way to the sea which it demands. Another great nation desires a place in the sun, the freedom of the seas, or a fair share of colonies in distant lands, the colonies being desired for purposes of trade and colonization of its emigrants. But in time of peace this same nation extends its trade by leaps and bounds to every corner of the earth freely and has the utmost freedom of the seas, and sends its emigrants in great numbers to prosperous North and South America. It is only in time of war that the opportunities for trade of that country are limited or that it would profit by having its emigrants under political control. Colonies again in distant parts of the earth may be desired for coaling stations but it is only in time of war that the ships of a nation can not coal freely anywhere.

Still another country desires to retain or regain disputed territory, although in time of peace probably no citizen or group of citizens in its own or in the coveted territory would have its opportunities in any way enlarged or its condition benefited by mere political transference. The acquisition of territory is, again, a common excuse for war, but it has never been shown that, under our modern conditions, the citizens of larger states are any happier or wiser or wealthier than the citizens of smaller states. Thus we have the vicious circle; war exists because of war.

War being thus outgrown and wholly irrational and having no longer any possible purpose except to perpetuate itself, and being opposed to the spirit of the age and discouraged by the powerful peace movements of the day and directly adverse to the all-controlling and all-absorbing industrial and commercial interests of the world, it would seem that it must soon disappear from the face of the earth. But strangely

enough such an outcome, happy as it might be, is made probable neither by the study of history, psychology nor present political tendencies. To the psychologist, indeed, it appears that the whole trend of social movements is in a direction favorable to the perpetuation of war.

One hundred years ago there were bright visions of universal peace. War, it was believed, was an iniquitous invention of evil and mischievous men, interfering with the peace and prosperity of the world. Free trade between nations and free competition between men were to inaugurate a reign of universal peace and prosperity. The function of government was to be limited to a minimum. A sort of universal fraternity, pan-humanism or internationalism was to take the place of fratricidal strife.

This dream has been poorly realized. Free competition has not worked in practise, and the emphasis is being put more and more upon the functions of the state. To be sure many would substitute "society" for the state and, indeed, socialists and Utopianists still look forward to a "new basis of civilization" in which a pleasure economy is to replace the old pain economy, when surplus energy, equality of opportunity, increase of food, short working hours, good sanitation, good housing, etc., will release starving human faculties, resulting in human culture, morality, economic equilibrium and finally in a "denationalized fraternal humanity." Thus with the disappearance of poverty the last obstacle will be removed to upward human progress and universal peace.

It is the purpose of this paper to point out some of the psychological obstacles to the realization of this ideal. Meanwhile it is obvious that the political obstacles are equally great.

At the present time the trend of political events is precisely in the opposite direction. With the unification of Italy in 1859, there awoke the new spirit of nationalism and the revival of patriotism. In 1861, the American Union, fired by the same spirit, resisted disunion. Then followed the unification of Germany, the awakening of the Slavs, the expansion of Great Britain.

Instead of the anticipated free trade between nations, each country by means of protective tariffs drew the mantle of self-sufficiency more closely around itself. In place of the expected pan-humanism a new patriotism has everywhere sprung up. Add to this another fact, perhaps correlated with it, that in the last hundred years a new impulse of cosmic energy, or something of the kind, seems to have flowed into the motor nerves of human beings. There is tremendous activity in the form of striving. The gospel of striving which dates from Lessing and Fichte, and which found its poetic expression in Goethe, is the gospel of modern life. It exhibits itself in intense desire for expansion, for self-expression. It has produced stupendous results in scientific invention, discovery, industrial and commercial expansion. Then fol-

lows the desire for political expansion and the occasion for war is at hand. The gospel of striving inevitably leads to the gospel of strife.

While to a superficial observer the whole tendency of modern thought is in the direction of universal peace, to the more careful observer it is all in the direction of war. It was not even necessary that the voice of Nietzsche with his gospel of the will to power should be reechoed through every land, nor that the new philosophy of Pragmatism should come forward to teach us that nothing succeeds like success.

But perhaps the war in Europe is itself the best witness to the fatal political obstacles which stand in the way of these dreams of peace, for it presents the astonishing spectacle of the greatest war in the world's history proceeding from the least apparent causes and in the face of the most powerful forces working for peace. That such a colossal war should occur under circumstances so adverse to war would seem to indicate that it was made necessary by some tremendous issues, either moral, religious, economic or commercial.

But strangely enough no such issues are apparent. There were no great moral issues involved, as in the American Civil War, no great religious questions as in the crusades and the wars of the Reformation, no great monetary crises, as in some of the Italian and Roman wars. Starvation has sometimes led tribes or nations to war, but starvation threatened none of the present warring countries. On the contrary they were all in a highly prosperous economic condition. Wealth, prosperity, comfort and luxuries abounded. "Never since the world began," says Albert Bushnell Hart, "was trade so broad and profitable as in the year 1913." The total value of international commerce was in that year $42,000,000,000. The total value of German exports and imports combined was $5,000,000,000; and of English, $6,900,000,000. Germany's actual and proportional trade was increasing from year to year. England was exporting goods to Germany valued at $292,000,000, and importing goods from Germany valued at $394,000,000 yearly. The entrance of Italy upon the war revealed only too clearly that war has its roots in psychological causes more than in great political or economic issues or in heroic defence of the fatherland.

Does this strange situation admit of any explanation? Or must we say that there are forces at work in social evolution which we do not understand—that it is dangerous for man to meddle too much with his own destiny, and that out of these terrible wars some great good may come in ways unknown? This question may not be answered, but at any rate some light is thrown upon the situation by the psychologist. In all the many books and articles that have recently appeared on the causes of war in general, and the European war in particular, there is a noticeable failure to take due account of the psychological factors in the situation.

As a single typical illustration let us consider the illuminating articles by Mr. G. Lowes Dickinson entitled "The War and the Way Out," published in recent numbers of the *Atlantic Monthly*.

Mr. Dickinson traces the causes of war to the artificial rivalries between those abstract and unreal beings called states, rivalries which are wholly unshared by the real men, women and children who compose the state. The actual citizens of the state desire to live in peace and quiet, to till their land, sell their produce, and buy their necessities, and are but little interested in the question whether the shores of the Baltic shall belong to Russia or Germany or whether Constantinople shall be controlled by one nation or another. Nor indeed do these political relations make any material difference to the people themselves; they make a difference only to that idol, the abstract state, and then only in time of war. The remedy, therefore, is to be found, first, in the cessation of these international rivalries, second, in the international control of armaments, and third, in the elective allegiance of disputed territory, such for instance, as Poland, Alsace and Lorraine. The cause of war being thus removed, the peace-loving, law-abiding and land-tilling citizens will live in happiness and prosperity.

This program is most captivating and no one can doubt that if international rivalries could be prevented in this way, the immediate cause of many wars would be removed. But the greater number of the wars of history have not been between rival states but have been wars of conquest and civil wars and the real causes of them all lie deeper than in any political relations, deeper than the love of conquest, deeper than in any economic or commercial complications. All these alike are the occasions and not the causes of war.

Mr. Dickinson regards the state as an abstraction, in a way unreal, and not having necessarily as its interests the interests of the real people who compose the state. This is true but Mr. Dickinson's constructive program rests, if not upon an abstraction such as the political state, nevertheless upon a myth, namely the myth of the peace-loving, law-abiding and land-tilling citizen, who, if opportunity offers, will till his land and buy and sell his goods in peace and prosperity. This quiet, peace-loving and land-tilling citizen, if not quite a myth, is at any rate not typical of the modern citizen. The typical man of to-day has not, to be sure, any conscious desire for war nor any wish to violate the laws of the state, but he is an exceedingly complex product of biological evolution, of modern civilization and of social forces, and in his own brain may perhaps be found the real powder-magazine responsible for war. The man of to-day is a high-tension being, with a highly organized brain, possessing an immense amount of potential energy in a state of rather unstable equilibrium, the product of an evolution which has discovered the survival value of certain peculiar mental qualities. Beneath this

superior brain, and sometimes perilously near the surface, there lies a vast network of inherited dispositions connecting the man of to-day with his warlike savage ancestors.

In place, then, of this unreal social unit, the peace-loving, land-tilling citizen, we have the real man, the restless and aggressive man, who loves the city rather than the country, frequents the stock exchange, the theater and the moving-picture show, likes to speculate and gamble, is fond of rapid transit by means of steam or trolley car, automobile or aircraft, passes much of his time indoors, reading, writing, planning and contriving, delves into new problems of philosophy, science and invention, exploits new lands and new routes of trade, invents new guns and new explosives, devises new methods of rapid communication and transportation, is addicted to the use of tobacco and alcohol and strong coffee and tea, is subject to chronic fatigue, has a tendency to the use of poisonous drugs and to insanity and suicide and small families.

This is our typical man of to-day and beside him and living in close proximity to him, there is another class, likewise neither peace-loving nor land-tilling, namely, the class of dependents, delinquents, and defectives.

This then is the material we have to work with, and now, given this material, let us suppose that international rivalries should cease, that our colossal modern armies and navies should disappear and that the vast number of men and the enormous amounts of capital involved in military armaments should be turned into productive channels, and let us suppose further that the burden of taxes hitherto required for armies, navies, and pensions should be lifted and with it lifted also the fear of invasion, —what then would happen? Something very different, no doubt, from that condition of idyllic happiness and peace which one infers from the arguments of the pacificists.

The fact is, the causes of war lie much deeper than in any political conditions. They are to be sought in the constitution of the human mind. The question, therefore, is a profoundly difficult one and demands a different method of approach. It must be approached from the biological and psychological as well as the sociological point of view. The following attempt to approach the subject from its psychological side is submitted in the belief that the facts here presented, while no doubt partial and incomplete, are facts which the student of the causes and remedies of war will have to consider.

To understand the psychology of war, it is necessary to go back and trace the actual history of the development of the human being. Here lies the trouble with all our schemes of pacificism and all our Utopias and all our pleasure and peace economies. They deal with an ideal human being, not with actual men. Sociologists will make futile contributions to human progress except as they keep in close touch with the facts of human evolution and of human history.

Some ages ago Nature, as we may say, made a great and wonderful discovery, that of the survival value of intelligence, supplemented later by the discovery of the survival value of sympathy and cooperation. It was no longer, thereafter, a question of tooth and claw, of swift foot, strong arm and warm fur; it was a question of the manufacture and use of weapons and tools and clothes and houses. Psychologically, it was a question of the development of certain new and wonderful mental traits, those of cunning and dexterity, attention and concentration, abstraction, analysis and invention. But these required a large brain, and Nature therefore produced an erect, top-heavy animal, who acquired speech and called himself man. Physically this animal ceased further development. He needed nothing but a large and ever larger brain and a dexterous hand, and, finally, the dexterous hand also was scarcely needed, but brain and brain alone. The brain, however, required nourishment and a certain physical support, hence stomach, heart, lungs, and a circulatory system must needs be retained after some fashion, but the main intent was to develop brain and only brain.

This process is now at its height. Nature we may say is more than ever elated at her discovery of the survival value of intelligence and this discovery is being worked for all that it is worth. There is no limit, it would seem, to the power of the mind. Other animal species are no longer feared. They are not even needed as servants. Electricity can be made to do all things better than the horse. Against intelligence the elements have no longer any power. Storm and lightning and flood are now only interesting episodes. Night is no longer a harbinger of evil but under the glare of the electric light a joy and great delight. Heat and cold are no longer to be considered. Steam and the electric current turn winter into benign summer and night into day. Neither is distance to be reckoned with any more. It is short-circuited by steam, gasoline and electricity.

Especially in continental Europe, in England and America, during the past fifty years, has the march of mind gone forward with dizzy-like rapidity. More than ever has man become master. More than ever are the higher brain centers the only significant organs in the body. Less than ever has Nature found it necessary for her immediate needs to care for stomach, heart and lungs, or muscle and reproductive system. It is mind that counts and mind alone. Nineteenth and twentieth century man has become a high-power efficiency machine combining a marvelous capacity for thought with an unconquerable force of will, but working inevitably under high pressure and dangerous tension.

A gigantic system of wireless telegraphy is not invented and extended over the whole face of the earth in a few years (one might almost say in a few months) without thought and effort. Dreadnoughts and superdreadnoughts, mortars and machine-guns, dirigibles and aeroplanes,

superb and matchless systems of military organization are not perfected without thought and effort. Magnificent cities, fed by a network of smoothly running railroads, are not built without thought and effort. Improved systems of agriculture forcing the earth to produce fourfold more abundantly are not devised without thought and effort. Miraculously wonderful cinematographic machines are not invented without thought and effort, nor without thought and effort is every moving thing from the Arctic to the Antarctic in nature and in art photographed and brought in its living and moving similitude to our eyes. Large continental cities are not freed from graft and brought under elaborately perfect systems of municipal government without thought and effort. Great national and international systems of organized labor are not perfected without thought and effort. The day laborer does not hold himself hour by hour and day by day and month by month to his highly specialized and fatiguing work without thought and effort.

These illustrations could be extended indefinitely. In the work of scientific research, in philosophical study, in industrial and mechanical invention, in the building of great systems of schools and universities, in the management of great commercial and industrial enterprises, in journalism, literature and art, we see exhibitions of ceaseless thought and tireless effort. It is an age of hard work and almost without exception it is mental work of a highly specialized kind and involves stress of the highest and most recently developed brain centers.

It was inevitable that disaster of some kind, or a reaction of some kind, should follow upon this high-tension and one-sided life. Something was bound to snap and something has snapped. Nature has overreached herself in her new discovery of the survival value of intelligence. Intelligence, to be sure, has a survival value of almost limitless degree, but intelligence is, as it happens, linked inseparably to a brain, a highly complex, delicate and unstable mechanism, which was originally intended as a motor center for hand, foot and somatic muscles, and not as a center for thought and sustained effort. Furthermore, the brain itself is organically dependent upon stomach, heart and lungs, whose parallel development Nature in her haste to develop her new discovery has neglected.

The form that the reaction has taken in this case is the form which the psychologist sees it must inevitably take, namely, the temporary reassertion of primitive human impulses. The world has had a thinking spasm of unusual severity; it must have a fling. In America, where conditions were much the same as in Europe, the reaction has taken the milder form of amusement crazes. The dance, the moving-picture show, the automobile, the diamond and the gridiron have helped to relieve the tension. The dancing mania, which has swept over the whole western continent like an obsession, is a good illustration of Nature's

effort to restore the equilibrium of brain centers. Dancing is a pastime as ancient as war itself. It involves none but the very oldest brain paths. It depends upon the very simplest and most primitive form of reaction, carrying us back to the infancy of man and allowing us to revel in the old and racially familiar memories. It affords complete rest and relaxation and tends quickly to establish equilibrium.

To those who do not understand this law of psychological compensation and who have been accustomed to regard the world as getting very serious and civilized and dignified, intent on moral and social improvement, there is something almost as ludicrous in the spectacle of dancing America as there is something pathetic and tragic in that of warring Europe. For in Europe, where the temper of the people lends itself less readily to these lighter forms of release, the reaction has taken the form of a return to most primitive bloodshed. Consequently the war came to us as a distinct shock. One heard everywhere the comment—"It is impossible. I thought we had got far beyond all that." The culture of Germany, France and England was so high that it was unbelievable that these people should suddenly develop hate in its most intense form with a frenzied desire to kill one another. To the psychologist, however, it seems not unreasonable. It is a temporary reversion to completely primitive instincts restoring the balance to an overwrought social brain.

Before the war we heard everywhere of "unrest," a great spiritual unrest. But the significance of this unrest was not understood. It was not due to untoward social or economic conditions, for the world has never seen conditions so favorable for the greatest happiness of the greatest number. Its cause rather was to be found in an asymmetrical development of human personality, too much thought, too much effort, too much "efficiency," and not enough balance, not enough mere somatic vitality. In England this unrest displayed itself as a high degree of social irritability. On the stage it appeared as a carping criticism of social life and social institutions; in literature as a hysterical pursuit of new Utopias; in political life as jarring rumors of civil war.

In Russia just before the outbreak of the war the streets of Petrograd were barricaded by strikers and progressives jealous of real or fancied wrongs. Instantly when war was declared a great inward "peace" settled down upon the warring nations. The restless soul ceased in a moment its feverish upward striving after new inventions, new philosophy, new science and new thought. The brain centers were short-circuited. The social mind sank to the old level. It lived again in the old primitive emotions and the old racially familiar scenes, in pictures of bloodshed and rapine, in memories of the drum-beat and of the tread of marching armies. To be sure there was sorrow and suffering and anxious faces and hunger and hardship and countless woes but these

are old friends to the human mind. The nation was at war but it was at rest. A certain strange harmony settled down upon the people. The war was hardly two months old when we began to hear of a new Russia, a new France, a new England and a new Germany, all regenerated by the baptism of blood, full of high aspirations, purified visions and noble resolutions.

To those acquainted with the psychology of play and sport, war is more easily understood. The high tension of the modern work-a-day life must be periodically relieved by a return to primitive forms of behavior, as in football, baseball, hunting, fishing, horseracing, the circus, the arena, the cock-fight, the prize-fight, and the countless forms of outing. Man must once again use his arms, his legs, his larger muscles, his lower brain centers. He must live again in the open, by the camp-fire, by the stream, in the forest. He must kill something, be it fish or bird or deer, as his ancestors did in times remote. Thereafter come peace and harmony and he is ready once more to return to the life of the intellect and will, to the life of "efficiency."

Periodically, however, man seems to need a deeper plunge into the primeval and this is war. War has always been the release of nations from the tension of progress. Man is a fighting animal; at first from necessity, afterwards from habit. In former centuries when the contrast between peace and war was not so great, it was undertaken with more ease and less apology, almost as a matter of course. Life was less intense then and the reaction of war less extreme. Now in the face of an advanced public sentiment, of peace societies and arbitration boards, the tension has to become very great, the potential very high before the spark is struck and, when this happens, we have the ludicrous spectacle of the warring nations apologizing and explaining to an astonished world.

War, therefore, seems to act as a kind of katharsis. The warring nation is purified by war and thereafter with a spirit chastened and purged enters again upon the upward way to attain still greater heights of progress. In strictness, however, the katharsis figure is misleading. The situation is not one of gross emotions to be purged away, as Aristotle implied. It is rather merely a question of fatigue and rest. Our demand for an ever-increasing efficiency has brought too great a strain upon those cerebral functions associated with the peculiar mental powers upon which efficiency depends. Efficiency demands great powers of attention, concentration, analysis, self-control, inhibition, sustained effort, all of which are extremely fatiguing and demand frequent intervals of rest and relaxation. When this rest and relaxation are lacking, we may always expect cataclysmic reactions which shall restore the balance.

In war, society sinks back to the primitive type, the primitive mortal combat of man with man, the primitive religious conception of God as

God of battles, and the primitive morality of right as might. It brings rest to the higher brain centers, it brings social relaxation, it brings release from the high tension which is the condition of progress. After the war, almost in a day, the nation resumes its accustomed moral standards, just as the debauchee returns to his daily life chastened and subdued.

If the theory of war here suggested is correct, it might be inferred that in modern times, as life becomes more rapid and more strenuous and the brain tension greater, wars would become more and more necessary to relieve the tension and restore equilibrium. It is true that with the heightening of mental life, relaxation of some kind becomes more and more imperative. But with the growth of intelligence the absurdity, futility, and unreason of war as a means of settling disputes becomes more and more evident and with the increase of culture and refinement and of Christian love and sympathy the spectacle of war becomes more and more anomalous and grotesque, so that we have in modern times powerful counteracting forces—forces which are still further augmented by the vigorous humanitarian movements of the times. The motives which make for peace are so great and the absurdity of war so apparent that the fact that wars continue quite as general and quite as frequent as in former times shows that the deep-lying psychological forces which lead to war are more powerful than ever.

In case some way is found to prevent international rivalries, if war between nations is made less and less possible by schemes of international arbitration and conciliation, why, then, it is probable, unless we also discover some method of diminishing the mental tension of our present mode of life, that "unrest," social irritability and probably civil wars will increase. Professor James was wholly right when he hoped for some substitute for war.

The fact is that it does not take a very careful reader of the human mind to see that all the Utopias and all the socialistic schemes are based on a mistaken motion of the nature of this mind.

In fact, it is by no means sure that what man wants is peace, and quiet and tranquility. That is too close to ennui, which is his greatest dread. What man wants is not peace, but a battle. He must pit his force against someone or something. Every language is most rich in synonyms for battle, war, contest, conflict, quarrel, combat, fight. German children play all day long with their toy soldiers. Our sports take the form of contests in football, baseball, and hundreds of others. Prize-fights, dog-fights, cock-fights have pleased in all ages. When Rome for a season was not engaged in real war, Claudius staged a sea-fight for the delectation of an immense concourse, in which 19,000 gladiators were compelled to take a tragic part, so that the ships were broken to pieces and the waters of the lake were red with blood.

You may perhaps recall Professor James's astonishing picture of his visit to a Chautauqua. Here he found modern culture at its best, no poverty, no drunkenness, no zymotic diseases, no crime, no police, only polite and refined and harmless people. Here was a middle-class paradise, kindergarten, and model schools, lectures and classes, and music, bicycling and swimming, and culture and kindness and elysian peace. But at the end of a week, he came out into the real world, and he said,

> Ouf! what a relief! Now for something primordial and savage, even though it were as bad as an Armenian massacre, to set the balance straight again. This order is too tame, this culture too second-rate, this goodness too uninspiring. This human drama, without a villain or a pang; this community so refined that ice-cream soda-water is the utmost offering it can make to the brute animal in man; this city simmering in the tepid lakeside sun; this atrocious harmlessness of all things,—I can not abide with them.

What men want, he says, is something more precipitous, something with more zest in it, with more adventure. Nearly all the Utopias paint the life of the future as a kind of giant Chautauqua, in which every man and woman is at work, all are well fed, satisfied and cultivated. But as man is now constituted he would probably find such a life flat, stale and unprofitable.

Man is not originally a working animal. Civilization has imposed work upon man, and if you work him too hard, he will quit work and go to war. Nietzsche says man wants two things—danger and play. War represents danger.

It follows that all our social Utopias are wrongly conceived. They are all based on a theory of pleasure economy. But history and evolution show that man has come up from the lower animals through a pain economy. He has struggled up—fought his way up through never-ceasing pain and effort and struggle and battle. The Utopias picture a society in which man has ceased to struggle. He works his eight hours a day—everybody works—and he sleeps and enjoys himself the other hours. But man is not a working animal; he is a fighting animal. The Utopias are ideal—but they are not psychological. The citizens for such an ideal social order are lacking. Human beings will not serve.

Our present society tends more and more in its outward form in time of peace toward the Chautauqua plan, but meanwhile striving and passion burn in the brain of the human units, till the time comes when they find this insipid life unendurable. They resort to amusement crazes, to narcotic drugs, to political strife, to epidemics of crime and finally to war. The alcohol question well illustrates the tendencies we are pointing out. Science and hygiene have at last shown beyond all question that alcohol, whether in large or smaller doses, exerts a damaging effect upon both mind and body. It lessens physical and mental efficiency, shortens life and encourages social disorder. In spite of this fact and what is still more amazing, in spite of the colossal effort now

being put forth to suppress by legislative means the traffic in liquor, the per capita consumption of alcoholic drinks in the United States increases from year to year. From a per capita consumption of four gallons in 1850, it has steadily risen to nearly 25 gallons in 1913. The increase in the last two or three years has been less marked, owing no doubt to the remarkable extension of "dry" territory, but this is offset by a great increase in the use of narcotic drugs and of tobacco.

Narcotic drugs, such as alcohol and tobacco, relieve in an artificial way the tension upon the brain by slightly paralyzing temporarily the higher and more recently developed brain centers. The increase in the use of these drugs is therefore both an index of the tension of modern life and at the same time a means of relieving it to some extent. Were the use of these drugs suddenly checked, no student of psychology or of history could doubt that there would be an immediate increase of social irritability, tending to social instability and social upheavals.

Psychology, therefore, forces upon us this conclusion. Neither war nor alcohol can be banished from the world by summary means nor direct suppressions. The mind of man must be made over. War is not social insanity nor is it even social criminality. It is too normal to be classed as either. But war is fast becoming irrational and a substitute for it must be found. Social reconstruction hereafter will have to be conceived on a different plan. It will have to be based on an intimate knowledge of psychology, anthropology and history, rather than merely upon sociology and economics. As the mind of man is constituted, he will never be content to be a mere laborer, a producer and a consumer. He loves adventure, self sacrifice, heroism, relaxation.

These things must somehow be provided. And then there must be a system of education of our young differing widely from our present system. The new education will not look to efficiency merely and ever more efficiency, but to the production of a harmonized and balanced personality. We must cease our worship of American *efficiency* and German *Streberthum* and go back to Aristotle and his teaching of "the mean."

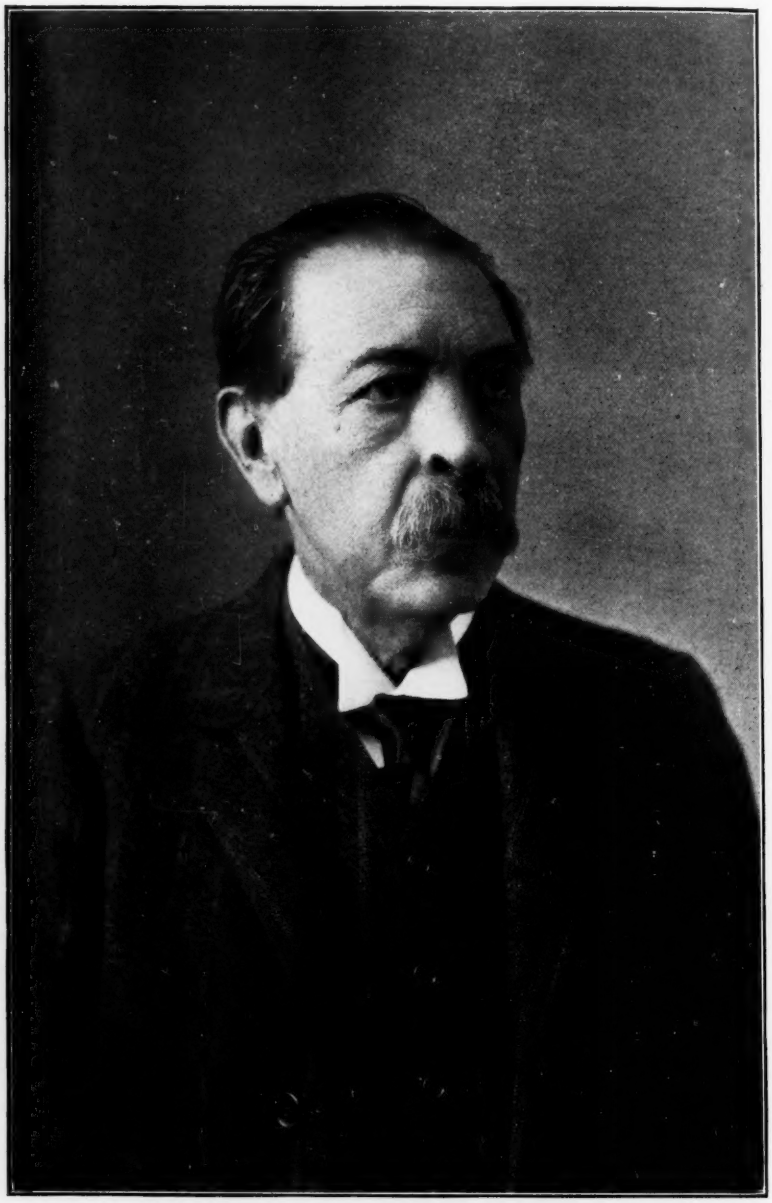
SOME PIONEERS IN MOSQUITO SANITATION AND OTHER MOSQUITO WORK. II.

By Dr. L. O. HOWARD
BUREAU OF ENTOMOLOGY

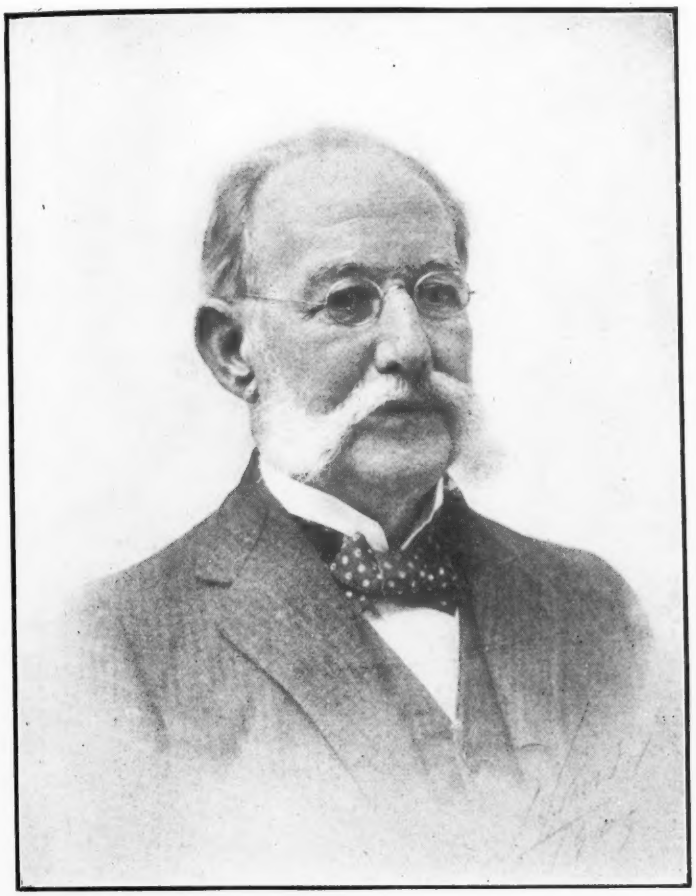
Dr. Oswaldo Conçalves Cruz, director of the Instituto Oswaldo Cruz, Rio Janeiro, Brazil. The work of the Oswaldo Cruz Institute in regard to the carriage of disease by insects has been of the highest type. The men are trained in all bacteriological and morphological methods, and their work has placed the institute among the first in the world. Dr. Cruz is responsible for the early and complete elimination of yellow fever from Rio Janeiro and for its reduction throughout Brazil.

Dr. A. Lutz, chef de service, Oswaldo Cruz Institute, Rio Janeiro, Brazil, formerly director of the Bacteriological Institute, São Paulo, Brazil; well-known worker in helminthology, pathology and bacteriology, as well as entomology; he has done much work on the mosquitoes of Brazil, and has conducted studies of great importance in regard to the relation of insects and disease.

Dr. E. A. Goeldi, professor of zoology in the Cantonal University, Berne, Switzerland, formerly director of the Museum at Para, Brazil, which he founded, and which is known as the Museu Goeldi. He published while in Brazil an elaborate monograph of the mosquitoes of that country, discussing these insects from every point of view.

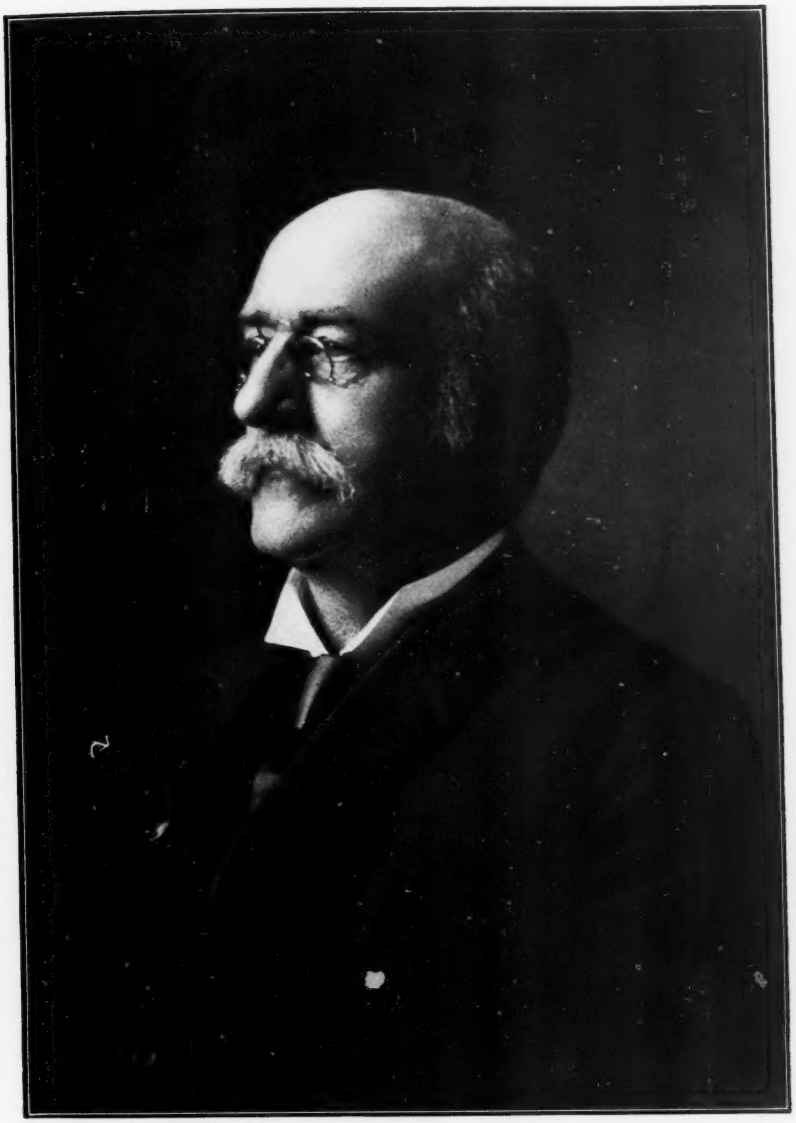


Dr. Eduardo Liceaga, president of the Superior Board of Health of Mexico; a very enlightened and progressive sanitarian of the highest scientific attainments. He immediately grasped the importance of the malarial and yellow-fever discoveries, and put into effect measures which soon rid the Republic of Mexico of all traces of yellow fever.



Dr. Carlos J. Findlay, president of the Board of Health, Havana, Cuba. Dr. Findlay early announced the carriage of yellow fever by a certain species of mosquito (the same one, in fact, which was definitely proved to be the carrier), but his experiments were not conclusive, and his conclusions were not accepted by the scientific and medical world until nearly twenty years later, when the U. S. Army Commission (Reed, Carroll, Lazear and Agramonte) brought about the overwhelming proof which was generally satisfactory. Findlay's announcement, however, was based on many years' study of the disease and of the mosquito vector.

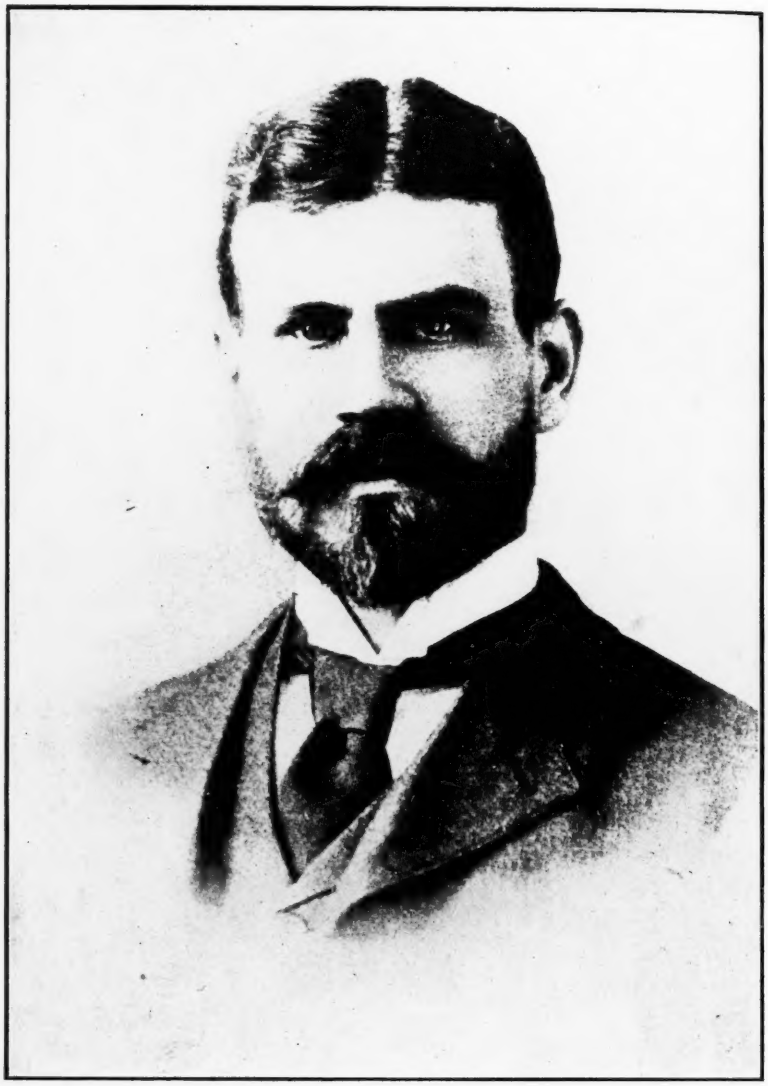
Dr. Aristides Agramonte, Havana, Cuba, professor of bacteriology and experimental pathology, Havana University, Cuba; president of the Board of Infectious Diseases, Cuban Sanitary Department. He was the only Cuban member of the U. S. Army Yellow Fever Commission which proved the transmission of yellow fever by *Aedes calopus* (formerly called *Stegomyia fasciata*) and is the only surviving member of the Commission.



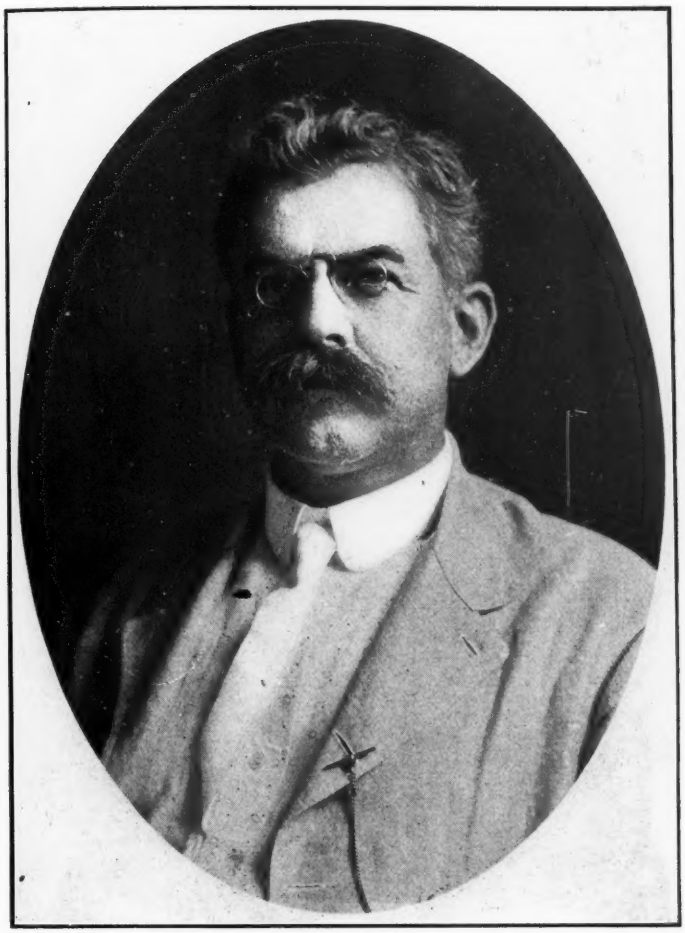
Dr. A. F. A. King. Dr. King was professor of obstetrics in Columbian (now George Washington) University, Washington, D. C., and a well-known Washington physician. He was a man of unusual mentality, and as early as 1883 published in THE POPULAR SCIENCE MONTHLY an extended article in support of the idea that malaria is carried by mosquitoes. His array of reasons was so great and his argument so convincing that his paper has been considered the very strongest of any on the carriage of disease by insects, published prior to the actual proof. He died December 13, 1914, in Washington, D. C.

Dr. Walter Reed, U. S. A., president of the U. S. Army Yellow Fever Commission, he who is to be given the principal credit for the scientific demonstration of the transmission of yellow fever by a mosquito. Dr. Reed died shortly after the complete demonstration was announced, his death being attributable in part to the strenuous work which he had done in connection with these investigations. He was always very loath to have his picture published, and for a long time the only one known was that taken in his early manhood, and which the writer used in an article in the *Century Magazine* of October, 1903. The present picture is evidently from a photograph taken not long before his death, and has been given to the writer by the Army Medical School at the request of Surgeon-General Gorgas.

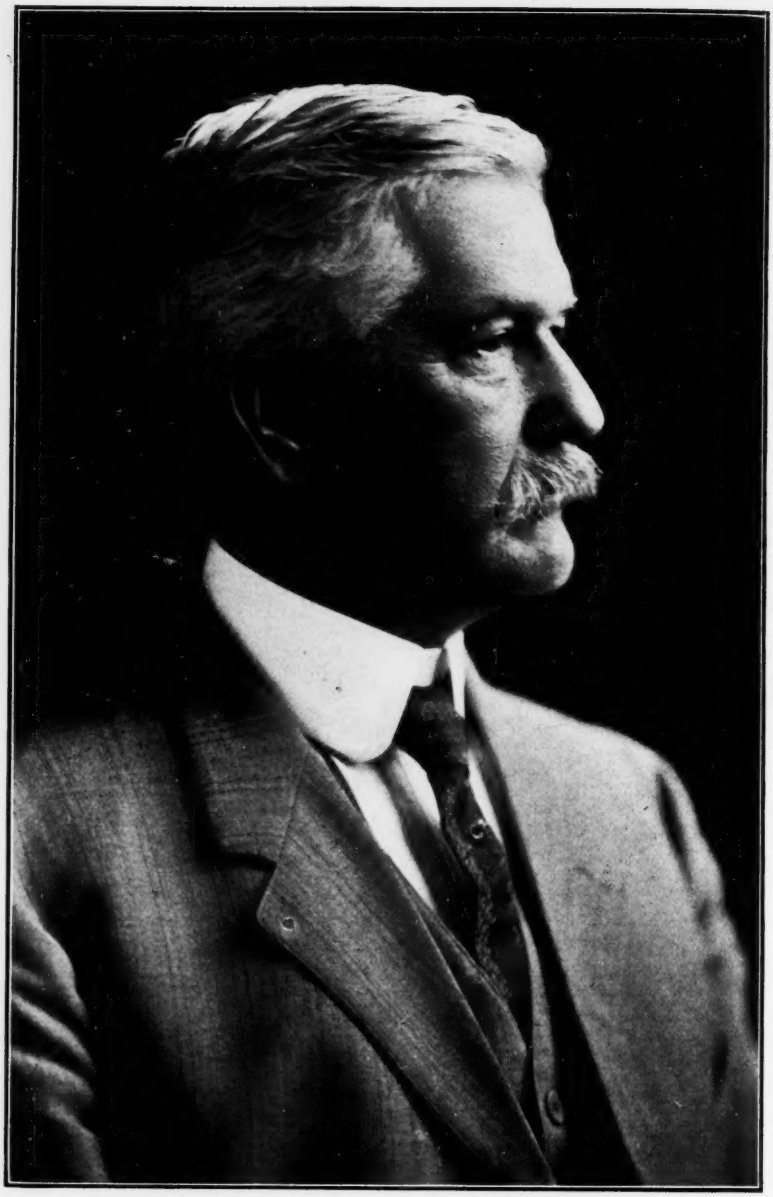
Dr. James Carroll, U. S. V., member of the U. S. Army Yellow Fever Commission. Dr. Carroll himself had yellow fever in the course of the investigation, as the result of a puncture by the yellow fever mosquito, and died a few years afterwards, his death being attributable in a large measure to the disease and to his hard work during the investigation period.



Dr. Jesse W. Lazear, U. S. V., member of the Yellow Fever Commission. Dr. Lazear was a Johns Hopkins man and died in October, 1900, during the progress of the investigation as the result of a bite of an infected mosquito.



Dr. J. H. White, assistant surgeon general, U. S. Public Health Service. In 1905 Dr. White was given full control by the national, state and city authorities of the yellow-fever epidemic in New Orleans. His work was done strictly on the mosquito basis, and the epidemic, which was fully started and which would certainly otherwise have resulted in thousands of deaths, was wiped out before frost for the first time in the history of yellow fever. The total death list was less than 500.



Dr. W. C. Gorgas, surgeon-general, U. S. Army. General Gorgas (then major) was the chief sanitary officer of Havana, in charge of sanitary work in that city from 1898 to 1902. He immediately grasped the importance of the discoveries of the Army Yellow Fever Commission, and put in operation methods of combating yellow fever, based upon the mosquito idea, which eliminated the disease in Havana. He was made colonel and assistant surgeon general by a special act of congress for this work. He was chief sanitary officer of the Panama Canal Zone from March, 1904, until the completion of the canal, and controlled yellow fever, malaria and other tropical diseases so perfectly as to prove beyond all peradventure the feasibility of an extended occupation of tropical regions by white races.

SOME ECONOMIC FACTORS INFLUENCING THE FORESTRY SITUATION

By A. F. HAWES

STATE FORESTER OF VERMONT

I

IN the movement for the conservation of our natural resources, which is now rapidly gaining strength in our eastern states, as well as in the national government, the influence of many factors must be taken into consideration, and the question may very well arise as to whether our representative form of government, as exemplified in our national congress, our state legislatures, and city councils, is sufficiently far sighted to cope with them. Can these cumbersome bodies, representing, as they do, the contending interests of the day, and having their eyes so closely focused on the present, look into the distant future and pass judiciously on measures affecting the next generation?

It has been a well-recognized policy, on the part of our local governments, to exempt new industries from taxation for a period of years on the ground that such an inducement would counterbalance any advantages that other towns had to offer, and that the new industry would be an unquestioned asset to the community. Very few industries, however, are so constituted that artificial benefits can compete with natural favorable conditions; such as nearness to the supply of raw material, transportation facilities, water power, and a ready supply of efficient labor. Even if these could be counterbalanced, the practise of tax exemption has become so general that it is quite as easy for an industry to secure it in one locality as another, and the result is a practise of community throat-cutting without any appreciable benefits. So long as the practise is tolerated it is, of course, impossible for single towns or cities to prosper without entering into this unfortunate scramble.

A still more important question is as to whether the proposed industries will be really beneficial to the locality in which they are established. They are, as a rule, beneficial or otherwise, according as they have the elements of permanency. That many lines of business of seeming permanency may fail, or after a few years' experience, remove to other places, is, of course, to be expected. So a business, which, by the nature of things, can exist only for a short time, may not be a damage to a community if it leaves that community no poorer than when it came. For example, a corn-canning factory may prosper in a

region just so long as corn production is a profitable line of agriculture for the farmers to pursue. But if some other crop becomes more profitable than corn, the new crop will be raised; or, if the value of dairy products rises proportionately higher than corn, the corn will be used for ensilage.

The removal of such an industry would not impoverish the community except in so far as the local people had invested in it. So a business which exploits without waste a mineral resource, the amount of which can never be increased, can not be considered blameworthy for the entire disappearance of the supply. It is very different when we consider a resource, such as timber, which, by proper handling, can be made permanent, and can be even increased from two to ten fold over its natural productivity. A company which enters a region with the intention of stripping off within ten or twenty years timber which has been one or two hundred years in growing, and which can not be regrown in less than three quarters of a century, is in much the same position as the gentleman swindler who entertains lavishly, pays generously for what he gets, but finally escapes with the wealth of his confiding friends. It is only fair to say that this does not apply to the lumbermen of the past, for, after all, business honesty is a very relative matter, and one can hardly expect a firm to conduct its business on principles in advance of public opinion. That interlocking directorates were in good repute a decade ago will not excuse such a condition in the future.

It will be apparent to any one considering permanent prosperity, that such an industry, removing in a wasteful manner a resource like timber, that could be handled in a better way, is anything but an asset to the community. Such a business not only should not be encouraged by tax rebates, but should be controlled by state regulations safeguarding the community from such disastrous results of a wasteful policy as may be seen in many deforested sections of the country.

Innumerable instances could be cited from various states of serious mistakes in public policy where injurious industries have been encouraged by tax rebates. One may suffice as an example. In a Vermont town there was a timber property that was assessed fifteen or twenty years ago at $40,000. For several years, while this timber was being removed, the saw-mill manufacturing it was exempted from taxation. The mill is now gone, and the real estate is assessed at $1,000. Many other properties have depreciated in the same way, and the inevitable result is a steady increase of the tax rate. Depopulation and degeneration are the natural results of such a policy.

II

Lumber prices in the past have not justified much attention to the growing of timber as a private business. It must be remembered that

these prices have never been based on the cost of growing timber, as are the prices of manufactured articles, upon the cost of production, but have been fixed by competition based simply on the cost of manufacture. While the price of lumber is to-day much higher than it was fifteen or twenty years ago, we must realize that a considerable part of this increase is due to the higher cost of labor, and the increased transportation charges, due to the inaccessible position of much of the timber now being cut. While the stumpage price has also advanced, it has not yet any relationship to the actual cost of growing, but only to the scarcity of, and demand for, the particular kind of timber. Only in the case of a few species, which are in particular demand, and which also happen to be rapid growing, are the prices sufficient as yet to cover the cost of growing. Under this heading may be included such species as the white pine, white ash, basswood and chestnut. On account of the serious disease of the latter it can not at present be advised for growing. Other species, which are almost equally in demand, and which sell for nearly as much, can not be grown for their present sale prices because of their slow rate of growth. As examples of these may be mentioned the hemlock, cedar, birch and maple. The first of these can probably be dispensed with, because its place can well be taken by more rapid growing species; but such species as cedar, birch and maple, which have peculiar qualities of their own, must, if they are to be perpetuated, eventually demand higher prices than the more rapid growing species, in order to compensate the raisers for the greater length of time required. Otherwise, the introduction of some substitute will be essential. Between these two classes is a group of trees whose growth is such that under favorable circumstances they may be profitably raised, but which, under conditions prevailing in many remote sections, can not be grown at a profit. The spruce, balsam, red oak, hickory and poplar may be mentioned in this class.

As the prices for slow-growing timbers must be relatively higher than for rapid-growing species, if they are to persist, so the prices for trees yielding the better grades and wider boards of a species must be considerably higher than for small, poorly developed trees. For some time we have had grading rules formed by various lumber manufacturers' associations for the grading of manufactured lumber, the different grades selling for different prices. This has not generally affected the prices paid for round logs or standing timber. In some localities, where there is a growing competition between wood-working industries for particular kinds of timber, there have been developed, of late, local grading rules for round logs. By these rules, which are similar to those which obtain in European countries, highest prices per unit of volume are paid for large logs free from defects, and the lowest prices for small defective logs with several gradations between. While the prices paid for these

various grades are as yet purely arbitrary, they tend to encourage the holding of the better trees for the higher prices. Eventually these prices must be based on the factors which go to produce these better grades, such as the added length of time, the labor expended in silvicultural operations, etc.

At all conservation meetings the cry is common among lumbermen that prices do not yet warrant the practise of forestry. That this is still true in the remoter regions is indisputable; yet the lumbermen should remember that they have only themselves to blame for the condition, since they have always pushed out into new fields faster than the lumber prices warranted. The public is little concerned whether or not a man can practise forestry profitably in one section of the country, if it is known that he can do so in the more accessible regions. The national production of lumber brings up a very nice question. It is well known among lumbermen that a slight overproduction results in a considerable drop in prices; which is, of course, fatal to the forestry cause. Yet we have the popular demand for cheap lumber and the strenuous opposition on the part of the government to any kind of an agreement among lumbermen to limit the output. In the same way the popular feeling is to-day undoubtedly in favor of no tariff on lumber on the ground that more Canadian lumber will be imported, and that our lumbermen will not be obliged to cut so much. As a matter of fact Germany and other countries, which have paid attention to the growing of timber, have a tariff on lumber to protect their growers from countries like our own, which are wholly exploiters of timber, although at the same time a great amount of lumber is imported by their manufacturers. It should be the duty of some federal commission, possibly the Interstate Trade Commission now under discussion, to try to arrive at a compromise between producers and consumers, whereby the annual output would be sufficiently limited to eliminate waste and maintain prices high enough to warrant the practise of forestry; and, on the other hand, to protect the consumers against monopolistic prices.

III

Bonded indebtedness for railroad construction has been the bane of many a New England town. In the days when the United States government was subsidizing the railroads of the west, the farm towns of New England were raising every possible dollar to build their own railroads in the forlorn hope that in this way they could meet the competition with the fertile lands which a misguided government was giving away in the west. Voting year after year for unneeded protection against foreign nations, these farm peoples were betrayed by the politicians into a far more disastrous competition with cheap lands in the west, which no established community, with accompanying high values,

could resist. The general decline of farm values; migration of the population to cities and the west; the bankruptcy of railroads and similar events, are the chief incidents of the rural history of New England of the last generation. Many of the towns, still overtaxed by reason of long-standing railroad bonds, may well ask the question "whether the railroad was an asset or a liability." In not a few regions railroads were first constructed for the purpose of transporting lumber. If any thought were given to the future it was assumed that agriculture or some unforeseen industry would follow lumbering and would furnish business for the railroad. In many of these sections only a small portion of the soil is adapted for farming, and wood-using industries alone are possible in a community where lumber is the only natural resource. Is it then any wonder that many of these railroads to-day, after the timber has been removed, are on the verge of insolvency? It is too late to remedy this evil in many sections, but new railroads are still being built in the same old spirit of exploitation. Would it not be well for a state, in granting a charter for such a road, to make some provision for the conservation of the natural resources tributary to that road? Such a measure would not only safeguard the community traversed, but would be of inestimable benefit to the innocent stockholders of the railroad, upon whom the road would, sooner or later, be unloaded by the capitalists.

Some form of state control would work no hardship upon the people, if adopted in connection with better transportation facilities. It is a well acknowledged fact that adequate transportation alone makes possible the practise of forestry. Yet, because of the shortness of human life, and the still shorter human judgment, railroads in this country have always resulted in waste and desolation of forests, rather than in conservation and upbuilding, and only in a few cases, where the soil was particularly rich, has forest destruction been justified.

From the standpoint of railroading, there are few crops which furnish the promise for permanent railroad prosperity that is supplied by the timber crop of the well-managed forest. Under fair conditions of soil and management an annual production of 300 board feet per acre is easily obtainable. Let us assume a railroad, fifty miles in length, serving a region about thirty miles wide. If one third of this area is tillable, which is about the average percentage in New England, the total area which should be devoted to forestry would be 640,000 acres. The annual cut from this area would be about 190 million feet of lumber, or 10,000 car-loads, were it all shipped in a rough state.

The average freight rate on a car of lumber from Northern New England to Boston or Springfield, is about $50. Such a traffic would, therefore, be worth to the whole railroad system (although not to this one road alone) a half million dollars a year.

It is estimated there are in New England some twenty-five million

acres better adapted for timber production than for other purposes. If this were all utilized as described above, and one half of the lumber cut were shipped, while the other half was used locally, the railroads would move annually over 200,000 cars of lumber. Is it unreasonable to expect that railroad executives will spend more thought in the future on the conservation of tributary natural resources, and less on the manipulation of funds, than has been the case in the past? The only alternative may have been already foreshadowed by the action of the federal government in undertaking an extensive railroad policy in Alaska for the proper development of the immense resources of that territory.

More, perhaps, than any other class, the forester is concerned with the material prosperity of the future; not, however, from any narrow professional sense, but because of the far-reaching influence of such prosperity upon the development of the future people. He may, therefore, be pardoned for looking at some of these matters from a somewhat different angle from that in which they are usually regarded.

THE WASTE OF LIFE

By ELAINE GOODALE EASTMAN
AMHERST, MASS.

To bear a child is nothing; to suckle it, nurish it, bring it to perfection—this is bearing it for all time!—BALZAC.

THE conservation of human life stands next to the giving of life and inseparably one with it as the supreme task of woman. The birth rate is affected by so many different factors that conclusions must not be hastily drawn from any given set of figures. It may be lowered from voluntary or involuntary causes; by extreme want or excessive luxury; by diseases of immorality, or by the higher education of women. It was formerly highest in the centers of population, but this condition is being reversed, and the rural birth rate is falling less rapidly than the urban.

The death rate among young children, however, is actually a touchstone of community welfare; a test of civilization. A high rate of infant mortality means individual ignorance, and social injustice. A lowering of the rate denotes a definite and positive improvement in living conditions, a prevention of economic waste and human suffering comparable only to the total abolition of war in magnitude. The number of babies dying from neglect in the United States alone, would about equal in three years the total number of soldiers killed on both sides during our Civil War!

When we ask how many died in any one year, we find, first of all, our vital statistics greatly modified in value by the surprising fact that effective registration of births and deaths is not yet general throughout this country. From the latest report of the Census Bureau (1911) we learn that birth registration is especially unsatisfactory, and that probably not over one fourth of our population is represented by records even approximately complete. The National Federation of Woman's Clubs is cooperating actively with other organizations and with the Census Bureau itself in the effort to remedy this defect, through the enactment and adequate enforcement of standard laws in the several states. The new Children's Bureau of the Department of Labor, under Miss Julia Lathrop, is bringing additional support to this important movement. It is by no means creditable to us that the accuracy and uniformity of our vital statistics should compare thus unfavorably with those of the civilized nations of the Old World.

The rate of infant mortality has been defined by experts as the ratio of deaths during the first year to the total number of births, and not, as sometimes figured, the ratio of deaths during the first year to the number of living infants under one year of age. For the group of registration states as a whole, the infant death rate calculated under the latter plan was about eight times the death rate at all ages. The death rate of children in the first five years of life was about ten times that of children in the second five years. It is estimated that approximately three hundred thousand babies die annually in the United States before reaching their first birthday. In terms of total population, this means the annihilation of a great city the size of Chicago, or of a state like New Jersey, in a single decade. And at least half of these little lives are needlessly lost. In New York City, in the year 1910, there were 125 deaths under one year for every thousand births; in Washington, D. C., 152; in Lowell, Mass., 231; in Seattle, Washington, only 82! The wide variation is sufficient proof that many, if not most of such deaths are preventable.

Stillbirths have been unaccountably neglected in vital statistics, frequently being counted neither among births nor deaths. In American cities, it has been estimated that 4 per cent. of all babies are born dead, most of them from preventable causes. We do not know the number of miscarriages (also mainly preventable), nor of ante-natal murders, which frequently pass undetected. In France, the number of criminal abortions has been reckoned at fifty thousand to one hundred thousand a year.

Causes of Infant Mortality

It has sometimes been said that the elimination of the feebler children, such as are often exposed to die in savage lands, tends on the whole to the advantage of society. On the other hand, it is important to remember that the causes productive of a high rate of mortality also affect the resistive power of those who survive and sensibly weaken the next generation. Our aim must be to insure that all be well born, and all work for the preservation of the lives of little children helps in the realization of this aim, as will be seen by an analysis of the causes of death. About 10 per cent. of all who die within the year live less than one day, and nearly one third perish before the end of the first month, showing that prominent among the causes of infant mortality is the mother's condition before and during the birth, as affected by alcoholism, social disease and maternal overwork. These same evils tend to produce stillborn and defective children. There is also extended lack of proper care during confinement. In American cities, it is said that about one half of all births are attended by midwives, 90 per cent. of whom are inefficient (Mangold).

The next greatest cause, and one depending partly upon the former,

is the lack of maternal nursing. It has been estimated that as many as 70 per cent. of the infants in New York City are bottle-fed, and therefore have only about one tenth the chance for life of the breast-fed child. Some of these mothers are physically unable to nurse their babies, by reason of ill-health, overwork and under-nourishment; but many more could do so if they sufficiently realized the importance of the service.

A third leading cause, operating, of course, among bottle-fed babies and after weaning, is the use of impure milk. Bad air, flies and all other unhealthful conditions naturally affect the babies more quickly than the adult population; yet experts agree that the health of the mother, her successful nursing of her child for several months, at least, and failing this, a supply of clean, sterile cows' milk, are factors of first importance.

To sum up, we find that from one sixth to one tenth of American babies die before they are one year old, and that more than half of these, perhaps nearly all of them, perish because of maternal ignorance or carelessness, or, more fundamentally, because of unjust social conditions and laws which fail to protect the makers of the new generation. It is full time that the mothers of America were roused to a sense of their grievous, their criminal neglect.

The Mother's First Duty

First of all, there ought to be an active propaganda among women concerning the importance of maternal nursing. Such a movement is needed most in the so-called educated class, since it is estimated that 60 per cent. of well-to-do women employ artificial feeding, and only about 20 per cent. among the poor. The causes underlying the decline of the American family, such as inordinate love of ease and pleasure, the entrance of women into industrial and professional life, and certain diseases of over-civilization, are doubtless responsible for much of this deterioration in the quality of our motherhood. Yet the convenience and attractive appearance of the various widely advertised baby-foods, and the common use of the obnoxious nursing-bottle, have blinded many mothers to the truth, and not a few allow themselves to be persuaded by meddlesome friends or pretty pictures that this is the modern, sanitary way of bringing up children!

Let every young wife be told bluntly that the woman who fails to nurse her child is but half a mother, and that she deprives herself of one of the sweetest pleasures in life, while robbing her little one of its birthright and enormously reducing its chances of survival, and its vigor if it lives. Tell her that artificial feeding is ten times more troublesome and inconvenient than natural feeding; and that the bottle-fed child, though fat and apparently well-nourished, is far more likely

to succumb to infantile diseases, a frequent prey to rickets, and almost certain to be backward in teething, walking and talking. Moreover, a physician of wide experience has said that disuse of the mammary gland has a tendency to manifest itself in the next generation when the baby girl in turn becomes a mother, while the reverse is equally true. Impress upon her the fact that the milk is often slow in coming, and that nearly all mothers can, if they persevere and are in fair health, nurse their babies for at least three months, while a full year is better. Let it be thoroughly understood that bottle-feeding is a grave misfortune if unavoidable and, if avoidable, an unnatural wrong. Let anything and everything which may be found to interfere with this essential function—as social dissipation, overwork and worry, either before or after marriage,—be relinquished in favor of that simplicity of living and wholesome attitude toward life which should restore and preserve a normal American womanhood.

A Shining Example

The progressive little state of New Zealand has for some time boasted the lowest rate of infant mortality in the world. It was reported in 1912 at 51 per 1,000 births, or less than half the (estimated) rate for the United States as a whole. During the years from 1907 to 1912, it is said that the rate in Dunedin, a city of about sixty thousand inhabitants, was reduced 50 per cent. through the activity of a volunteer society called the New Zealand Society for the Health of Women and Children. It is earnestly to be hoped that organizations of women in this country will follow the example and methods of this society, which are described for our benefit in a pamphlet issued by the national Children's Bureau. Taking a few of our oldest cities and states for purposes of comparison, we find that in Connecticut and Massachusetts more than twice as many babies die out of each hundred born; in Rhode Island, three times as many! In the city of Dunedin, during the past year (1913), only 3.8 died in every hundred; in Los Angeles—one of our very best cities—9.7; in Pittsburgh, Pa., 15; in Lowell, Mass., *23!*

The New Zealand society, though a private organization, receives the benefit of government aid and influence. Here, as elsewhere, the cooperation of public and private agencies has proved an effective means of social reform. The main features of the program for public health affecting our subject, are: (1) State registration of nurses; (2) registration of midwives; (3) government maternity hospitals; (4) supervision of infant asylums; (5) complete registration of births.

The society is officered by women and its work is mainly educational. It consists of the instruction of mothers and potential mothers through demonstration lectures, newspaper articles, pamphlets, etc.; the employ-

ment of specially qualified nurses to visit and instruct mothers before and after the birth of their children, and the promotion of needed legislative reforms. It announces itself as

> less concerned with reducing the death rate than with improving the health of the people. However, *the problems are practically identical.*

Work at Home

These and similar methods have been followed to some extent in a few American cities, in part by boards of health, and in part by various private agencies. Already the increase in scientific knowledge, and the new social consciousness, have resulted in a marked reduction in our infant death rate within the last few years. It is estimated that during the decade 1900–1910 the decrease was 19 per cent., or nearly one fifth, which of course satisfactorily offsets, in a measure, the reduction in number of births. The mother's contribution to the world is not to be measured by the number of children she has borne, but by the number brought to a vigorous and useful maturity.

In order to make all the knowledge collected on this subject generally available, to induce comparisons, and to enable one community to profit by another's experience, the Children's Bureau has issued the first of a projected series of annual bulletins on "Baby-Saving Campaigns in American Cities." The lack of financial support is the greatest obstacle to efficient work. The motto of the health department of New York City is worthy of note.

> Public health is purchasable; within natural limitations a community can determine its own death rate.

These significant words should hang upon the walls of every city hall in the land.

Surely nature's first law should be man's first concern, not only for himself, but for the community; not for his own children alone, but for all children, since none can be safe where all are not safe. Legislator, tax-payer, what would you take in exchange for the life of your child? How much are you willing to give in order adequately to safeguard its precious life and all the other precious lives in your community? A certain city of more than a half million inhabitants wrote to the Children's Bureau through its board of health as follows:

> We have *no funds available* to organize a division for the care of infants.

Another large city, on being asked its plans for a summer campaign against children's digestive diseases, replied:

> We have been unable to get an appropriation for a campaign of this kind.

Wherever this state of affairs exists—and may it not be in our own community?—it is incumbent upon individual women to organize, or

through existing organizations to compel public attention to this vital matter. The final responsibility lies with the public, and the outcome of successful private work is usually that sufficient municipal funds are appropriated to take it over. This has been accomplished in Bridgeport, Conn., Milwaukee, Indianapolis, Philadelphia, Baltimore, Richmond, Va., and in many other cities and towns.

While methods vary in different localities, the program for a baby-saving campaign, as outlined by the Bureau, is something like this:

1. Insistence upon complete and prompt birth registration as a basis of work. In some cities, a letter or card is sent each mother upon the birth of a child, thus securing her interest, and with the letter of congratulation a folder may be enclosed, containing advice on the care of infants, and printed, if desirable, in several languages. A strong appeal for breast feeding is always a feature of such advice.

2. Rigid inspection of the milk supply, with frequent tests for fat contents as well as for dirt and bacteria. Recognized grades of wholesome milk include: (*a*) certified milk; (*b*) inspected milk; (*c*) pasteurized milk.

3. The establishment of pure-milk stations, where such milk may be obtained at or below cost, and to mothers unable to pay the price may be furnished free. Such milk must be supplied only on proof of inability to nurse the child, if too young for proper weaning.

4. Baby clinics, and the employment of trained nurses to visit the homes, especially of the very poor, both before and after the birth of a child, to care for sick babies, and to instruct mothers in the care of infants.

5. Improvement of bad housing conditions; the fight against flies and the breeding of flies; and general educational work.

Dr. Josephine Baker, of the New York City Board of Health, has stated that

> babies may be kept under continuous supervision at a cost of sixty cents per month per baby, and the death rate among babies so cared for has been reduced to 1.4 per cent. In other words, the solution of the problem is twenty per cent. pure milk, and eighty per cent. care and training of mothers.

The American Association for Study and Prevention of Infant Mortality owes its existence to the American Academy of Medicine, which called the first conference on that subject ever held in the United States. The association was organized at the close of this meeting, held at Yale University in 1909, and in 1910 an office was opened in Baltimore, from which the work has since been directed. Its functions are chiefly educational, and its work is carried on by general propaganda, by investigations and special work in committees, through an annual meeting and the publication of its transactions, and through a traveling exhibit. Any person interested in the aims of the society may become a member, and the dues are three dollars a year and upward.

Besides the forms of work already mentioned, this association lays stress upon the importance of better teaching of obstetrics in our medical schools, upon the extension of maternity hospitals, out-patient obstetrical services, visiting obstetrical nurses, and either the thorough education or gradual abolition of midwives, also pre-natal instruction of expectant mothers. Many mothers lose their health or their lives, and more babies perish or become permanently crippled or blind, as a result of improper management during child-birth.

Why Poverty is Fundamental

The first field study of the Children's Bureau has just been published (1915), and inaugurates a proposed series of studies in infant mortality, to be made in typical American communities. It was undertaken by means of personal interviews with the mothers of all the babies born in the city of Johnstown, Pa., during one calendar year, 1,551 in all, of whom 196 died, or 134 per 1,000 births. The estimated rate throughout the United States is 124 per 1,000 (U. S. Census Report, 1911), which may be compared with a rate of about 261 in Russia, 105 in England, 75 in Australia, and 51 in New Zealand.

Owing to the method of enquiry, and to the absence of a physician upon the staff of the bureau, only family, social, industrial and civic factors were considered in Johnstown, omitting all reference to two important causes of infant mortality—alcoholism and venereal disease. Emphasis is placed upon the economic factor, and it plainly appears from a study of the tables presented, that, whatever the immediate cause of death, the underlying cause in a large majority of cases was that mother of all evils, poverty.

A study of environment shows that the death rate was 271 per 1,000 babies in the poorest sections of the city, or more than five times that in the best residential sections. It was 171 for foreign mothers as against 104 for native mothers. It was 214 for illiterate foreign mothers, or 66 per 1,000 greater than for foreign mothers who could read. The duration of the mother's rest period before and after confinement was found to affect the result, as was also the employment of a midwife instead of a physician. But most of these points depend directly upon the fundamental question of income. The father's earnings were discovered to be the one factor of greatest importance. Babies whose fathers earned ten dollars a week or less died at the rate of 256 per 1,000, while those whose fathers earned $25 or more a week died at the rate of 86 per 1,000. The foreigners, especially the recent arrivals, were generally those who lived in the poorest and most unsanitary quarters, whose women were ignorant and overworked, forced to carry water, to keep lodgers, or to work for wages, and all these misfortunes were commonly due to the lack of a proper living wage for the men.

Although only 47 per 1,000 died of the babies breast-fed at least three months, as against 166 per 1,000 of the artificially fed, even this advantage was outweighed by the terrible handicap of poverty, as will be at once recognized when we recall that about three times as many of the poorer mothers nurse their babies as of the well-to-do. The death rate among the illegitimate was about twice that of the legitimate, a difference generally recognized as due to almost universal abandonment of such children by the father, and frequent abandonment or neglect by the helpless girl-mother.

The disease directly causing most deaths was found to be bowel trouble or enteritis (usually caused by improper feeding, especially in summer), closely followed by the respiratory diseases (most fatal in winter), and prematurity or congenital weakness, causing death usually within a few days. About 5 per 1,000 were stillborn.

To sum up, although a certain amount of treatment of symptoms may be necessary or desirable, we should bear steadily in mind that whatever tends to modify social inequalities and to give to labor a fair share in the products of labor will do most to save the lives of three hundred thousand babies, yearly offered up in America an innocent sacrifice to the Moloch of selfish greed. And since the whole social body must suffer with the least of its members, is not the idol as short-sighted as he is hideous?

WAR AND THE PROGRESS OF SOCIETY

By Professor I. W. HOWERTH
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WE in America are so accustomed to the idea of social progress, and so familiar with certain actual or so-called progressive ideals, progressive factors and progressive movements, not to speak of progressive parties, that we are likely to assume that progress is general and in the nature of things. Such, however, is not the case. There are no grounds for the prevalent belief in the "general evolution of mankind" in which the nations of Europe, our own country, or any other country for that matter, must necessarily participate in spite of its wickedness, excesses and folly. The very idea of social progress is comparatively new, and the most superficial examination of the facts of social evolution as revealed in history will show that social advancement is sporadic, local and limited in time. Primitive civilizations were as a rule non-progressive. Some of the modern nations, as for instance, China, are practically in a statical condition. National decadence, or the reverse of progress, as for instance in the later history of Spain, Rome, Greece and Egypt, looms large in the background of the past. Extensive regions in the Orient, once the home of advanced civilizations, are now barren deserts from which all life has disappeared. National decadence is in fact a more familiar phenomenon than national progress. As Maine remarks,

> The stationary condition of the human race is the rule, the progressive the exception.[1]

Still, if the doctrine of social evolution be true, and we assume that it is, progress has characterized all peoples at some time in their history. Even in the case of stagnant primitive peoples, as well as the non-progressive nations of to-day, there must have been advancement prior to the time at which they reached their static condition. A brief study of the manner in which this advancement was brought about, particularly the part that war played, and now plays, in the achievement of social progress is the object of this paper.

It is sometimes said, and it seems to be widely believed, that one of the essential factors in social progress is war. This declaration and this belief, however, are unwarranted, as I shall proceed to show.

If we should look into sociological literature to find a specification of the factors of social progress and an accurate analysis of the several circumstances, elements or influences which tend to the promotion of civilization through progress, we should find practical agreement, al-

[1] "Ancient Law," p. 23. See also Bagehot, "Physics and Politics," Ch. I.

though the distinction between factors, forces, means and methods is not always carefully drawn. Buckle, in his "History of Civilization in England" attributes social changes, hence progress, to climate, food, soil and the general aspect of nature. Buckle, however, regards only the external factors of progress; and inasmuch as he holds that physical agents are the primary and the chief factors in human development, he anticipates the modern advocates of the materialistic conception of history. John Fiske says:

> The prime factors in social progress are the community and its environment.

By environment, Fiske means to include not only the climate, soil, flora and fauna, perpendicular elevation, relation to mountain ranges, length of coast-line, character of scenery and geographic position with reference to other countries, but also "the ideas, feelings, experiments and observances of past times, so far as they are preserved by literature, traditions or monuments, as well as foreign contemporary manners and opinions so far as they are known and recorded by the community." He does not attempt to analyze his conception of "community." Professor Carver in compiling his "Hand-Book for Students of Sociology" arranges his material under the following heads: the physical and geological factors, the psychical factors, the social and economic factors and the political and legal factors. In still another classification we find the factors of social evolution divided as follows: physical and geographical, biological, hygienic and eugenic, genetic and economic, political and legal, ethical and religious, esthetic, intellectual and associational.[2]

The literature of the subject aside, however, we need only to glance at the social process to see that the factors at work in the advancement of society are external and internal. The external factors arrange themselves under three heads, namely, the physical, the vital and the societal. The physical factors include soil, climate, topography, etc.; the vital include the regional flora and fauna; and the societal, the surrounding social groups that in one way or another exercise an influence on a given society. The internal factors consist in two things, and two things only: they are men and the things that men have made, or, somewhat less exactly, ideas and the embodied results of ideas in language, literature, the sciences, the arts, law, property, the state, religion, etc. Chief among the internal factors the one indeed from which all others are derived, is the intellect acting as a guide to the will. Professor Ward is practically correct when he declares that it is through the cooperation of the will and the intellect that civilization has been brought about. At all events, these are the great and comprehensive internal factors of civilization and progress.

In presenting these classifications of the factors of social progress, I am not concerned merely with their completeness or accuracy. I wish rather to bring out two significant facts: First, that the factors of prog-

[2] Bogardus, a syllabus entitled "An Introduction to the Social Sciences."

ress are many, and hence in attempting to account for social progress we should be careful not to overestimate the influence of any single factor; and, second, that in none of the foregoing classifications of the factors of progress is there mention of war. Why is war omitted? Is it because in the analyses it has been overlooked? Or is it because it may not properly be included among the factors of progress? Clearly the latter is the explanation. War is not a *factor* of social progress. This will be obvious on considering the real meaning of the term "factor."

If we turn to a definition of the word factor we find it means anything that is employed in the production of a given result. Thus, three is a factor of eighteen. It may be employed in the production of that number, but the manner or method of its employment may be either addition or multiplication. Now it is quite worth while in the interest of clearness of thought on the present subject to make a distinction between the factors that unite or that are employed in the production of a given result, and the manner in which these factors naturally combine or the method by which they are employed in producing that result. Clearly three and six, the factors of eighteen, are quite different from the addition or the multiplication, that is, the method, employed in producing the number. Observe, too, in this connection that while the number of factors that combine or are employed in the production of a given result may be and in general are fixed, the method of employing them is variable. It may be a natural and fortuitous reaction, which is really no method at all, or if consciously employed the methods may be as many and as varied as human ingenuity can devise. With exactly the same factors which by natural reaction or by conscious employment produce a given result, methods of employing them may be accepted or rejected in accordance with our judgment with respect to their effectiveness. We may eliminate what we consider bad methods and employ only what seem to us to be good methods, while the factors may remain the same.

In the case, then, of progress, or its opposite effected by war, the factors are the social groups involved, the war itself being merely the manner in which these factors combine to produce the given result. Is this mode of combining properly to be called a method? That is to say, is war a method of social progress? If war is a method of social progress it is clearly not the only method. Hence it is subject to comparison with other methods as to its relative efficiency. Its value as a method must depend upon its cost and effectiveness as compared with the cost and effectiveness of other conceivable methods of social progress, as for instance education, commerce, contact through travel, and the various other forms of intercommunication by which alone one social group may stimulate the progress of another. If, on comparison, a better method were found, it would show lack of social intelligence not to discard the worse for the better.

But a further consideration will show that war is not really a method of social progress, except in a figurative sense. For method, as De Greef properly observes, is the highest manifestation of knowledge and consciousness;[3] or, as Spencer remarks, the highest self-conscious manifestation of the rational faculty. It implies always and everywhere the perception of an end to be reached, and the conscious selection and employment of the means of reaching it. Before war can properly be regarded as a method of social progress, then, social progress must be conceived as the end to be realized, and war must be entered upon with the conscious intent of thereby promoting social advancement. It is hardly probable, however, that any nation has ever deliberately declared war with the conscious aim of promoting social progress, and it is not likely that any nation ever will do so. Unless and until this is done war, while it may be employed from time to time as a method of attaining governmental, class, or dynastic ends, can not properly be classified as a method of *social* progress.

We have seen then that war is neither a "factor" of progress, nor, properly speaking, a "method" of social advancement. It follows that it is not a "means" of social progress. For a means, strictly speaking, is something chosen for use in the achievement of an end. It implies method. It is that which mediates between the existing condition and the purpose to be achieved. Until some government, nation or society sets up social progress as an aim, and selects war as the agency for bringing it about, it is just as improper to speak of war as a means to social progress as it is to speak of it as a method or a factor of social progress.

So much for what war is not. It is sufficient perhaps to show that what is asserted of war as "an essential factor of progress," an "indispensable method of social advancement," etc., is incorrect, and that the widely prevalent conception of the necessity of war in the promotion of "kultur" and civilization is not well founded—is in fact mere *unsinnige Reden.*

But if war is none of the things already described, what is it? Plainly it can not be argued out of existence. In addition to being a frequent occurrence in the past, it is just now a very conspicuous and stubborn fact. What, then, is its real nature as a social phenomenon? and what is its true relation to progress?

From the social standpoint war is manifestly a form of group interaction. The nations involved have collided while in pursuit of what is regarded as their own individual well-being. War, then, is always entered upon, not with the large and generous object of promoting social progress, but in order to realize one or the other of the narrower and conflicting purposes of social groups. Social progress is not the conscious end, although any of the nations engaged will be ready to identify its own "cause" with progress, and with all that is precious in

[3] See Introduction, "A la Sociologie," p. 441.

civilization. This means that war is a socially unconscious phenomenon. As distinguished from the conscious and concerted, that is to say, artificial, action of society in the promotion of its own well-being, it is a purely natural phenomenon, and socially considered belongs in exactly the same class as earthquakes, floods, famine and pestilence.

To this point we come, then, that war has nothing to do with social progress, except in an incidental way. It is a mode of collective action whose incidental effect may be progress or regress. It is, as De Greef has well said, the best example of a socially unconscious phenomenon. He says:

> La guerre est le phénomenène social inconscient par excellence; la preuve, c'est qu'elle finit toujours par où on aurait dû commencer, si l'on avait été capable d'établir la balance exacte des forces hostiles, c'est-à-dire par des traites.[4]

"But," it will be said, "it can not be denied that war has sometimes resulted in progress." Certainly not; nor can it be denied that it has sometimes resulted in regress. As a result of war states have been founded, and as a result of war states have been destroyed. War has initiated civilizations, and war has overthrown them. And always the effect on social progress has been incidental, unforseen and unintended.

The social effects of war, then, and hence its influence upon progress, are exactly parallel to the effects of the undirected forces of nature. These in their blind action produce results sometimes progressive and sometimes the opposite, but always with absolute disregard of the effects produced and of the amount of energy expended. War, it may be said, belongs to the economy of nature and not to the economy of mind.

Now the common characteristic of the phenomena of nature as distinguished from the phenomena of mind, so far as they are related to the achievement of the ends desired by human beings, is waste. Nature is notoriously prodigal. Progress achieved by it is uncertain, slow and expensive. War, therefore, being from the social viewpoint a natural phenomenon should be expected to exhibit this common characteristic. And so it does. It is perhaps the superlative example of social waste.

Now waste, whether it result from individual or social action, is an evidence of unintelligence. The function of intelligence is to promote economy of time, means and energy in the realization of a given end. Social intelligence, therefore, when it is directed to the promotion of social progress, can not countenance war because of its wastefulness, to say nothing of the uncertainty of its results. Social progress, after the dawn of social intelligence, is really equivalent to the development of such intelligence. The general progress of society must therefore necessarily lead to the social prevention of war. Continuous progress with the continuance of war is a contradiction in terms.

[4] *Op. cit.*, p. 434.

THE FUNCTIONS OF PRIMITIVE RITUALISTIC CEREMONIES

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IF we take a naïve attitude toward primitive ritualism, we must wonder how it ever came about that people believe the proper method for attaining any desired end to be the use of a formula. Thus, we may note a Dakota Indian tossing a handful of dust into the air when going into battle to ensure victory, and wonder how a people, who otherwise impress one as intelligent, could possibly entertain so absurd a belief. Again when we see a primitive doctor singing and demonstrating a ritual over a sick man, we are moved at its pathetic folly. These things are incomprehensible to us chiefly because we can see no reason why the activities involved in the demonstration of a ritual can be considered as directly contributory causes to the ends desired. So long as we confine our attention to isolated cases of ritualism like the preceding our amazement will not abate, but if we examine in detail a large number and variety of primitive rituals, the phenomena become far more intelligible.

One striking feature of primitive ceremonials is the elaboration of ritualistic procedure relating to the food supply. Particularly in aboriginal America we have many curious and often highly complex rituals associated with the cultivation of maize and tobacco. These often impress the student of social phenomena as extremely unusual but still highly suggestive facts, chiefly because the association seems to be between things that are wholly unrelated. Thus among the Pawnee we find an elaborate ritual in which a few ears of maize are raised almost to the status of a god. At a certain fixed time in the autumn the official priest of this ritual proceeds with great ceremony to the field and selects a few ears according to definite standards. These are further consecrated and carefully guarded throughout the winter. At planting time the women present themselves ceremonially to receive the seed, the necessary planting instructions, etc. Thus, it appears that during the whole yearly cycle there is a definite ritual in function associated with maize culture.[1]

Again in the tobacco cultures of the Crow and the Blackfoot Indians, respectively, we find a close parallel. In the former case the ritual is expressed in the organization of a society whose chief function seems to be the direction and control of tobacco production. In the latter, the

[1] The reader wishing a good detailed example of maize rituals should scan the writings of Frank H. Cushing, particularly in volume 9 of "The Millstone."

ritual while no less elaborate is objectively associated with a ceremonial bundle, in which the seed is kept and guarded by the official keeper of the whole. In both cases each important step in the process from seed to pipe is one of the fundamentals in a ritual. Many such examples can be found in the special literature of the subject.

If now we give our attention exclusively to planting rituals certain points of general import may be noted. As a convenient example, we may abstract the following from the data on tobacco culture among the Blackfoot Indians: At the planting of the tobacco seed the leading men hold a feast to which they invite their friends. Eight young men are sent out to gather deer, antelope and mountain-sheep dung. They use this dung because these animals run fast and therefore the tobacco will grow rapidly. They do not use the dung of the elk and moose because the animals walk slowly and would thereby delay the growth of the tobacco. The leading men give a feast which lasts four days, during which they dance and sing. The dung is then mashed up together with service berries, and tobacco leaves and water are added. All these make the tobacco seed ready to plant. The seed is now given out among the planters. To prepare the soil a lot of brush is gathered by all the men, women, and children and spread on the ground. At each of the four corners of this place a fire is started, four men watching the fire so as to prevent it from spreading further. After all the brush has been burnt, they make small brooms of brush with which the place is swept clean. Then a number of men procure sticks with curved roots or having curves that can serve as handles. The straight end of this stick is sharpened and used for digging up the ground. With these sharpened sticks they make holes about a foot apart and two inches deep in a row and the ground is divided up into sections in which each man plants his seeds. The seeds are dropped into these holes, the children covering them up by running back and forth over them four times. Should a child fall while doing this, ill luck would surely follow, and the child will die. After the seeds have been planted incense offerings are made on the four corners of the plot and the songs of the ritual sung.

This part of the tobacco ritual is clearly but a formal expression of the recognized method of planting tobacco. We see that the seed is prepared for germination, the seeds and roots of all intrusive plants killed by burning over the surface, the soil leveled and pulverized, then effectively fertilized and the seed planted in a definite way. What after all is the ritual in this case, but a formalized statement of how tobacco should be planted to secure a good crop?

We also note the existence of specific knowledge of the conditions for tobacco growing, which certainly deserves to be considered scientific. The problem then arises as to how this knowledge came to be associated with a ritual. While we have no direct data as to how the Indian arrived at this knowledge, there is no good ground for believing that it

was developed by the construction of a ritual. So far as can be seen, knowledge that works, even among primitive men, is always arrived at by experimentation. Though it is likely that in this particular case the Blackfoot Indians learned the whole process from strangers, it is certain that each step in the process was originally worked out in some definite locality and the working out of these methods, while in a large measure due to the experience of many, quite likely received its final formalization at the hands of a single individual. This individual was the teacher.

Assuming that this is the condition leading to the formalization of the tobacco-planting procedure, and that it is fundamentally based upon material experiment, how can we account for the seemingly useless ceremonial accompaniments? In the case of culture traits like the tobacco planting of the Blackfoot Indians the problem is always complicated by already existing patterns, or method concepts. Thus it may come to be regarded as axiomatic that to succeed any process must be carried out in a ceremonial manner, or that mere social usage demands that it be so. If either or both of these conceptions prevail, it is clear that the original formalizer of the tobacco planting process would give it a ceremonial dress by introducing into it the more or less conventionalized ceremonial units prevailing in his group. If it was the custom of his people to give some weight to peculiar personal dreams, then also some of his dream experiences might be incorporated. The total construct then resulting would be a tobacco-planting ritual of which the Blackfoot example is typical. Yet this complication need not obscure the essential factor in the case, for, eliminating this "following of existing patterns," we have revealed the backbone of the ritual, the concrete demonstration of processes empirically determined.

Perhaps if we compare the conditions among primitive groups with those under which we ourselves live the case may be clearer. If tobacco planting as a new agricultural trait should be introduced to us, its demonstrator would reduce the necessary directions to writing or cast his oral directions in a form easily reduced to writing. Such writings would then be credited by some authority to furnish the sanctions for the procedure, take certain conventional forms as books, periodicals and lectures, and conform to a certain standards of literary style. Thus we should construct what may be considered a text-book, which, whether written or not, would take the same essential form.

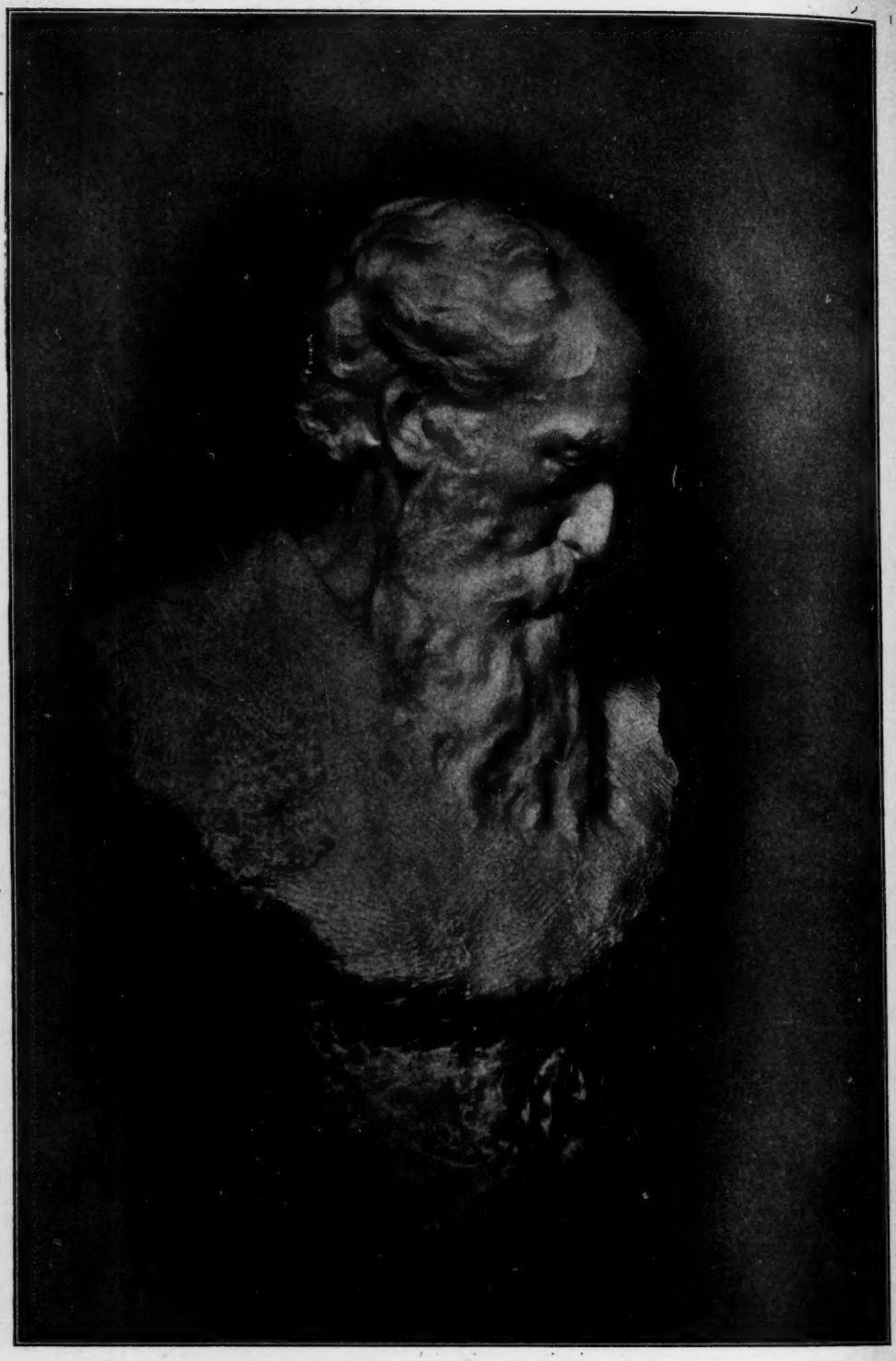
Now, among primitive groups the machinery for perpetuating and standardizing knowledge of this kind is the ritual. The objective method of written records not having been developed, we find in its place a memorized formula whose seriousness and sanction seems to be found in its ceremonial setting. We may safely conclude then that one of the chief functions of a planting or hunting ritual is the perpetuation of the method involved and that whatever may have been the conditions underlying its inception, it grew naturally out of the perpetuation of the

method by instruction. There is no reason to believe that it arose primarily as a ceremonial act, but that it must have been the result of homely experiment.

If we take the widest sort of view of the world there appears no good reason why primitive men should not be considered as great materialists as we fancy ourselves to be. Our anthropological museums are filled with the débris of primitive man's endless experimentation with stone, bone, shell, clay, pigment and metal. In all this one can often trace more or less clearly the successive triumphs of great inventors. Out of this boundless striving, step by step, doubtless hesitatingly and slowly, was built up the world's present store of real knowledge. For ages and ages and even yet, much of it was carried and perpetuated as a mere matter of memory. To distinguish between the essential and the inessential in a procedure is rarely easy, the great human way being to "follow the leader" in every detail, thus naïvely doing the necessary along with the irrelevant. Thus we are able to form a satisfactory theory of ritualism. It is based primarily upon empirical data, for the universal human method has always been "to try it." The experience of all mankind is, that wonders can be worked only by proceeding in certain precise ways, the real reasons for which are often utterly baffling. The person who knows the way can bring the result by merely going through with the formula. It is true even now that many who see the curious workings of these formulæ generalize and conceive of a universal method which is essentially the application of a formula. When such a conception becomes a part of folk-thought, we may expect individuals to experiment and try more or less at random formula of their own devising or, what is more likely, borrowed from another. Thus it comes to pass that many misfit formulæ in use everywhere.

The survival of true misfits in the more material affairs of life is unlikely, but when formulæ are applied to psychological and physiological phenomena, it is very difficult to decide as to their efficacy. A strong corrective influence works in one case in contrast to a weak one in the other. One scarcely need be reminded that our own scientific method developed first in strictly material problems and is but gradually extending its methods to the outlying phases of organic phenomena; and doubtless, here too many naïve and over-generalizing individuals misapply the mere empty methods of material science to the deception of themselves and others.

In short, a ritualistic ceremony in primitive life, and perhaps everywhere, is based upon a methodological ideal of accuracy in procedure or experiment and is an expression of a specific series of procedures so dressed and arranged as to hold the interest, emotions and retentive activities of men. Its primary function is to perpetuate exact knowledge and to secure precision in its application.



JOHN BURROUGHS.

This bust of the naturalist by the sculptor C. S. Pietro has recently been presented to the American Museum of Natural History, New York, by Mr. Henry Ford.

THE PROGRESS OF SCIENCE

THE PACIFIC COAST MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE first meeting of the American Association for the Advancement of Science west of the Rocky Mountains is an event of more than usual importance for science in America. It signifies both the development of a great scientific center on the Pacific Coast and the unity of the scientific interests of the country. It is also the case that the disastrous events in Europe will probably give the United States the leadership in scientific research and in the application of science to the advancement of civilization, and in a sense this new position and responsibility will date from the Pacific Coast meeting of the American Association and its affiliated societies.

It will be remembered that the March issue of THE POPULAR SCIENCE MONTHLY was devoted to the scientific work of the Pacific Coast and at that time there were given accounts of the organization of the Pacific Division of the American Association and of the national meeting to be held this summer in California. It is now needful only to remind readers of these events, and to urge the importance of a large attendance from all parts of the country.

The opening session for the presentation of the addresses of welcome, for announcements and for the presidential address by Dr. W. W. Campbell, director of the Lick Observatory, will be held in San Francisco at 10:00 o'clock, Monday morning, August 2, in the Scottish Rite Auditorium, corner Sutter Street and Van Ness Avenue. The social reception to visitors will occur on Monday evening in the reception rooms of the California Host Building, Exposition Grounds. The general sessions of the association, including three lectures on Pacific region subjects, will be held in San Francisco in the Scottish Rite Auditorium on Tuesday, Thursday and Friday evenings. The sessions of the association and of the affiliated societies on Wednesday, August 4, will be at Stanford University. It is expected that a special train will leave San Francisco at a convenient hour Wednesday morning for Palo Alto and return to San Francisco late in the afternoon. All other sessions of the week will be held at the University of California, in Berkeley.

The general headquarters of the association during convocation week, August 2 to 7, will be in the Hearst Mining Building, on the campus of the University of California, Berkeley. Secondary offices will be maintained: in San Francisco from Saturday noon, July 31, to Friday noon, August 6, in the Palace Hotel; in San Francisco on Monday forenoon, August 2, in the Scottish Rite Building, Sutter Street and Van Ness Avenue; and in Stanford University on Wednesday, August 4. Members will secure badges and programs upon registration. Mail addressed in care of the Hearst Mining Building, University of California, will be delivered as promptly as possible to those who have registered.

Several of the affiliated societies have announced selections of hotel headquarters as follows:

American Astronomical Society and the American Mathematical Society, Hotel Claremont, Berkeley.

American Physical Society, Hotel Claremont, Berkeley.

Geological Society of America, Paleontological Society of America and Seismological Society of America, Hotel Shattuck, Berkeley.

Botanical Society of America, Hotel Carlton, Berkeley.

Zoological Society of America and the Biological Society of the Pacific, Hotel Carlton, Berkeley.

Entomological Society of America, Hotel Claremont, Berkeley.

American Anthropological Association, Hotel Carlton, Berkeley.

American Genetic Society, Hotel Claremont, Berkeley.

American Psychological Association, Hotel Plaza, San Francisco, Post and Stockton Streets.

Archeological Institute of America, Hotel Bellevue, San Francisco, Geary and Taylor Streets.

Round trip special Exposition railway tickets at greatly reduced rates are available from all points to San Francisco, Los Angeles or San Diego as the destination. The price of tickets from points east of the Rocky Mountains is the same whether the destination be San Francisco, Los Angeles or San Diego. The trip going and returning may be by the same route or by different routes, but the routes described on the tickets must be followed. Tickets from Chicago and farther east are valid going or returning via New Orleans. Tickets via Portland, Seattle, etc., involve a supplementary charge, concerning which the local railway representatives should be consulted. The baggage of those who intend to stay in Berkeley should be checked directly to Berkeley, California (by either the Southern Pacific or Santa Fe routes) instead of to San Francisco. All round trip tickets require validation for the return trip.

Railway rates have been greatly reduced, the cost of a round trip being $62.50 from Chicago and $94.30 from New York.

Special lines of steamers advertise passage between the Atlantic and Pacific Coast by way of the Panama Canal at rates varying between $135 and $198 (one way).

Stop-overs for side trips can be arranged either going or returning. Round trip rate from San Francisco to Hawaiian Islands and return by either of several lines of steamers from $110 up. Yellowstone National Park is reached from Livingston on the Northern Pacific (to Gardner and return $3.20). A six-day trip in the park from Gardner costs $40 and another of 5¾ days $53.50. Yellowstone Park may also be reached from Ogden on the Union Pacific by a branch to Yellowstone (round trip $9.25). From here a five-day trip in the park costs $35 and a six-day trip $40.

The Yosemite National Park is reached by Southern Pacific or Santa Fe lines, stopping at Merced, Cal. Round trip from Merced to Valley $18.50. Both hotels and comfortable camps may be found at the camp. Several groves of Big Trees may be visited from the Valley. One grove very much visited is only six miles from Santa Cruz (on the Southern Pacific).

Alaska may be visited by steamer trip from Seattle or Vancouver. Round trip from Seattle $66 and up. From Prince Rupert (on Grank Trunk) a trip to Alaska may be made at an additional expense of about $30.

Attention may be called to two publications which will add to the scientific interest of the trip. The Pacific Coast Committee of the American Association has compiled a guide book entitled "Nature and Science on the Pacific Coast," which contains a large number of articles by leading men of science. The United States Geological Survey has prepared four guide books covering railway routes west of the Mississippi. These books, which contain full descriptions and excellent maps, may be obtained by sending one dollar for each to the Superintendent of Documents, Washington, D. C.

NATIONAL CONTRIBUTIONS TO SCIENCE

ART and religion, like language and customs, may be national, science is by its nature international. Each of the sciences and nearly every branch of

each science consists of contributions made over a long period of time and from widely separated places. One of the evil results in the universal disaster of this mad war is that the orderly progress of science is interrupted. Each week men of science are killed on the field of battle, and young men from whom science must be recruited die by the thousands. The universities of Oxford and of Cambridge boast that each has sent some 8,000 men to the war, and the average life of a British officer after he reaches the front is said to be thirty days. Almost as serious as the sacrifice of men is the loss of the wealth needed for scientific research, and perhaps more disastrous than either is the inevitable distraction of interest and unbalancing of judgment.

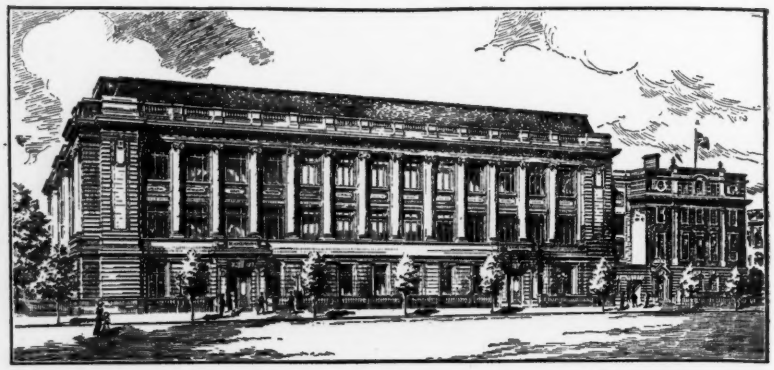
There is a marked disposition at present for the scientific men of England and France to disparage work which has been done in Germany, and conversely. It is consequently pleasant to read a discussion of this subject such as is contributed to a book on "German Culture" (Jacks, 1915) and to *Knowledge* by Professor J. Arthur Thomson of the University of Aberdeen, whose recent article on "Eugenics and War" in this journal will be remembered by its readers. He argues that Britain, France and Germany run neck and neck in their contributions to science, and illustrates this by a series of corresponding names which are here reproduced. It will be noted that the British names are arranged alphabetically and that for each is given a French and German equivalant.

British	French	German
Balfour	Lacaze-Duthiers	Roux
Dalton	Lavoisier	Bunsen
Darwin	Lamarck	Kepler
Davy	Legendre	Weber
Faraday	Fourier	Clausius
Fitzgerald	Becquerel	Hertz
Foster	Claude Bernard	Ludwig
Galton	Delage	Weismann
Graham	Berthelot	Liebig
Green	Galois	Gauss
Hunter	Cuvier	Gegenbaur
Harvey	Bichat	Humboldt
Hooker	de Jessieu	Sachs
Huxley	Buffon	Haeckel
Joule	Carnot	Mayer
Jenner	Bordet	Behring
Kelvin	Laplace	Helmholtz
Lankester	Giard	Johannes Müller
Lister	Pasteur	Virchow
Lodge	Ampère	Ohm
Maxwell	Poincaré	Boltzmann
Ross	Laveran	Koch
Burdon-Sanderson	Brown-Séquard	Bois-Raymond
Spencer	Bergson	Lotze
Smith, Wm.	Gaudry	Suess
Stokes	Lagrange	Cantor
Thomson, J. J.	Cauchy	Kirchoff
Weldon	Quetelet	Zittel
Wright	Richet	Ehrlich

It is easy to criticise any such selection. If we go back to Harvey, Newton should surely be credited to England, and if Kepler is included for Germany, there is no reason why Kant rather than Lotze should not be taken as its representative philosopher. The three contemporary zoologists and the two physiologists credited to England are scarcely among the world's great men of science. But Professor Thomson only claims to use a rough and ready method. His sets of names may be studied to advantage. As he remarks, if we could, as we can not, represent the merits of three counterparts—British, French and German—by the three sides of a triangle, the lengths would now be in favor of Britain, again in favor of France, and again in favor of Germany; yet a superposition of a number of triangles sufficiently large to get rid of conspicuous inequalities would yield a not very irregular figure.

THE NEW SCIENCE MUSEUM IN LONDON

WE take from the London *Times* a sketch and some description of the new Science Museum which is to be erected in London between the Natural History Museum and the Imperial College of Science. This building and the one at Munich are the first buildings to be especially constructed for museums of



physical science. The building here shown will occupy about one third of the space, the remainder of which will be left for future extension. When complete the exhibition space will consist of three large roof-lighted halls, 200 by 100 feet, with surrounding galleries on the first and second floors lighted from the sides and from a large central well. It is intended to exhibit the larger and heavier objects, such as locomotives and engines, on the ground floor of the new building.

The museum has a great collection of objects illustrating the history of discovery and invention and the principles of experimental and mechanical science. These include: The earliest steam engines constructed by James Watt for industrial purposes, Stephenson's "Rocket" locomotive, Symington's steam engine, which was the first to propel a boat, and the engine of the "Comet" steamboat. Arkwright's original spinning machinery, Wheatstone's electric telegraph apparatus and other machines and instruments of vast importance contributed by Great Britain to civilization.

Science collections were first arranged in the South Kensington Museum in 1857, but of the early mechanical objects and models the most important are those which were brought together in the Patent Office Museum and handed over to the Department of Science and Arts in 1883. The collection of scientific instruments and apparatus took origin when certain of the objects included in the loan collection of 1876 were deposited in the museum. This collection already includes many illustrations of scientific investigation and inquiry that are of historic interest.

SCIENTIFIC ITEMS

WE record with regret the death of Mrs. Matilda Coxe Stevenson, for the last twenty-five years ethnologist in the Bureau of American Ethnology; of Lieut.-Col. Charles E. Woodruff, U. S. A., retired, known for his publications on the effects of sunlight and other subjects; of Dr. Hugo Müller, F.R.S., past-president of the British Chemical Society, and of Sir A. H. Church, F.R.S., formerly professor of chemistry in the Royal Academy of Arts, London.

AMHERST COLLEGE at its recent commencement conferred its doctorate of laws on Professor Benjamin K. Emerson, class of 1865, for forty-five years teacher of geology in Amherst College. Wesleyan University has conferred the same degree on William North Rice, who was graduated from the institution fifty years ago.

SURGEON-GENERAL RUPERT BLUE, of the Public Health Service, was elected president of the American Medical Association at the recent San Francisco meeting.—Dr. Viktor von Lang, emeritus profesor of physics at Vienna, has been elected president of the Vienna Academy of Sciences.—Lord Fisher, former first sea lord of the British admiralty, has been appointed chairman of an "inventions board," which will assist the admiralty in coordinating and encouraging naval science.